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ABSTRACT

The report to Congress by the Interagency Committee on Learning Disabilities, required by the Health Research Extension Act of 1985, Public Law 99-158, provides a review and assessment of Federal research priorities, activities, and findings regarding learning disabilities. Included in the report is information on (1) the number of persons affected by learning disabilities and the demographic data describing them; (2) current research findings on the causes, diagnoses, treatments, and prevention of learning and prevention of learning disabilities; and (3) recommendations for legislation and administrative actions to increase research effectiveness and prioritize research needs. Chapter I provides a summary of Committee activities, while Chapter II summarizes testimony of 23 persons representing various associations and organizations and purposes. Results of a survey of member agencies of the Committee concerning programs, achievements, and perceived needs are contained in the following chapter. Chapter IV contains results of a review of the epidemiologic and survey literature on incidence and characteristics of learning disabilities. Current research findings in the following five areas are reviewed in the next chapter: neurobiology of learning and memory; specific developmental disabilities of reading, writing, and mathematics; developmental language disorders; social skills deficits; and hyperactivity/attention deficit disorder. Chapter VI contains the Committee's recommendations including the need to revise the legislative definition of learning disabilities and the proposal of a revised definition. (DB)

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LEARNING DISABILITIES

A REPORT TO THE U.S. CONGRESS

Prepared by the Interagency Committee on Learning Disabilities 1987

THE SECRETARY OF HEALTH AND HUMAN SERVICES
WASHINGTON, D.C. 20201

AUG 17 1987

The Honorable George Bush
President of the Senate
Washington, DC 20510

Dear Mr. President:

It is my pleasure to transmit to you a Report on Learning Disabilities as required by Section 9(a) of the Health Research Extension Act of 1985, P.L. 99-158. The legislation mandated the Director of the National Institutes of Health to establish an Interagency Committee on Learning Disabilities to review and assess Federal research priorities, activities, and findings regarding learning disabilities (including central nervous system dysfunction in children). The mandate further required that the Interagency Committee report to the Congress on its activities and include in the Report:

(1) the number of persons affected by learning disabilities and the demographic data which describe such persons;

(2) a description of the current research findings on the cause, diagnosis, treatment, and prevention of learning disabilities; and

(3) recommendations for legislation and administrative actions--

  (A) to increase the effectiveness of research on learning disabilities and to improve the dissemination of the findings of such research; and

  (B) to prioritize research in the cause, diagnosis, treatment, and prevention of learning disabilities.

This Report complies with the congressional mandate.

Sincerely,

Otis R Bowen M.D.

Otis R. Bowen, M.D.
Secretary

Enclosure

THE SECRETARY OF HEALTH AND HUMAN SERVICES
WASHINGTON, D.C. 20201

AUG 17 1987

The Honorable James C. Wright, Jr.
Speaker of the House of Representatives
Washington, DC 20515

Dear Mr. Speaker:

It is my pleasure to transmit to you a Report on Learning Disabilities as required by Section 9(a) of the Health Research Extension Act of 1985, P.L. 99-158. The legislation mandated the Director of the National Institutes of Health to establish an Interagency Committee on Learning Disabilities to review and assess Federal research priorities, activities, and findings regarding learning disabilities (including central nervous system dysfunction in children). The mandate further required that the Interagency Committee report to the Congress on its activities and include in the Report:

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Secretary

Enclosure

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EXECUTIVE SUMMARY

The Interagency Committee on Learning Disabilities (ICLD) was mandated by the Health Research Extension Act of 1985 (P.L. 99-158), and its establishment was announced in the Federal Register on March 11, 1986, by the Director, National Institutes of Health (NIH). Activities of the Committee are summarized in Chapter I. Highlights of these activities included a Public Hearing on October 15, 1986, and sponsorship, jointly with the Foundation for Children With Learning Disabilities, of a National Conference on Learning Disabilities on January 12-13, 1987.

For the Public Hearing, the ICLD invited all professional and volunteer organizations, associations, and non-Federal agencies known to have an interest in or concern for learning disabilities (LD) to make presentations. The purpose of the meeting was to gather data and hear the views of individuals and organizations, including recommendations, as they related to the mandate given the Committee by Congress. In the course of the proceedings, 23 persons made presentations, of which 17 were in behalf of associations, organizations, and non-Federal agencies. Testimony covered a broad range of interests and concerns, ranging from findings and needs in basic and clinical research, to accounts of experiences in clinical practice, rehabilitation, and remediation, including problems of families of affected individuals. The testimony is summarized in Chapter II.

P.L. 99-158 required the Committee "to review and assess Federal research priorities, activities, and findings regarding learning disabilities (including central nervous system dysfunction in children)."

To meet this need, the member agencies of the Committee surveyed their programs and achievements in learning disabilities, including opportunities and needs, for inclusion in this Report. Results of these surveys appear in Chapter III.

P.L. 99-158 also required the Committee to include in its Report an assessment of the number and characteristics of persons affected by learning disabilities. A review of the epidemiologic and survey literature on this topic was prepared by the staff of the Centers for Disease Control for consideration by the Committee; a summary of this review and the Committee's conclusions appear in Chapter IV. In the absence of good prevalence data, the Committee believes that 5 percent to 10 percent is a reasonable estimate of the proportion of the U.S. population affected by learning disabilities. It is clear that prevalence is somewhat higher among socioeconomically disadvantaged populations, and higher in males than in females. Further study is necessary to provide an accurate estimate of the prevalence of learning disabilities in this country. Such an endeavor should be preceded by the development of a consensus on the definition of learning disabilities, with inclusionary and exclusionary diagnostic criteria.

The January 1987 National Conference on Learning Disabilities focused on current research findings in five areas: Neurobiology of Learning and Memory; Specific Developmental Disabilities of Reading, Writing, and Mathematics; Developmental Language Disorders; Social Skills Deficits; and Hyperactivity/Attention Deficit Disorder. For each topic, an expert consultant commissioned by the Committee presented a review and description of recent research in that field related to the cause, diagnosis, treatment, and prevention of learning disabilities; identified gaps in knowledge; and made recommendations for future research. Each presentation was critiqued by expert discussants, and followed by discussions with the ICLD and with members of the audience. Summaries of the literature reviews and discussions of these five topics appear in Chapter V. The full texts of the literature reviews of recent research findings are contained in the Appendix volume of this report (printed separately).

Chapter VI of this report contains the Committee's recommendations to Congress, as mandated in P.L. 99-158. The recommendations are the results of the Committee's review and assessment of the testimony at the Public Hearing, of the commissioned literature reviews and proceedings of the National Conference, and of the surveys of Federal agency activities. As an initial step, the Committee (with the exception of the Department of Education representative) believes that the time has come to revise the legislative definition of learning disabilities in accord with what has been learned in the last two decades of research, and proposes such a revised definition. A discussion of the problems of definition and the Committee's proposed revised definition are in Chapter VI.

The Committee is pleased to report to Congress that the literature on learning disabilities, which is still somewhat fragmented and in the past has been dominated by competition between different theories and approaches, now contains a sufficiently large information base for interdisciplinary teams of investigators to devise broad and longitudinal multidisciplinary approaches that integrate and capitalize on what is now known. Large program projects and the creation of centers of research would provide opportunities to bring neuroscientists, biologists, geneticists, epidemiologists, anatomists, psychologists, physicians, educators, and others together for intensive multidimensional studies of various populations of learning disabled persons and of carefully selected subsets, as individuals as well as groups, along with normal control groups. The scientific community now knows enough to bring these various parts together through multidisciplinary collaborative efforts, which should include long-term studies of prevalence and treatment outcomes. A major goal of this research should be the development of a classification system that more clearly defines and diagnoses learning disabilities, conduct disorders, and attention deficit disorders, and their interrelationships. Such information is prerequisite to the delineation of homogeneous subgroups and the development of more precise and reliable strategies for treatment, remediation, and prevention.

This approach will improve the dissemination of research findings and remedy a generally perceived problem of information sharing. It will reduce cross-disciplinary gaps in communicating research findings and facilitate the transfer of information to practicing clinicians. It will also provide a resource for hospital-based, school-based, and community-based counselling and education of families affected by learning disabilities. To further remedy problems of information sharing, a formal system of information dissemination through a central clearinghouse should be implemented. Such a clearinghouse would facilitate communicating information to target populations in need of it, such as practicing pediatricians, parent groups, and trainers of teachers. A further means of both developing and disseminating information is through demonstrations of service delivery through regional, family-centered, community-based systems of care. The focus should be on development and dissemination of new techniques of serving LD children and adults and the integration of efforts to meet health, educational, and psychosocial needs.

The causes of most learning disabilities remain unknown. It is essential to understand the environmental and genetic factors that cause these disabilities, because true, primary prevention cannot occur until the causes are known. Since the majority of etiologic associations have derived from in-depth clinical, laboratory, and epidemiologic studies of patients affected with a disease, it is very important that such etiologic studies be made of persons with LD and appropriately selected control groups.

It is important to understand the mechanism by which environmental and genetic factors cause LD because a better understanding of the mechanisms will provide information that will be helpful in primary, secondary, and tertiary prevention. Substantial research into mechanisms should be in the basic sciences, especially the neurosciences. In order to identify and elucidate the mechanisms of learning disabilities, better knowledge is needed of how the brain develops and functions. Early brain development, for example, is a period of special vulnerability. Although neurotoxicity produced experimentally by exposure to chemicals is associated with learning and memory deficits, it is not known to what extent these exposures contribute to the human condition of learning disabilities. Research is needed, therefore, to determine when and how during ontogeny the cognitive processes, including learning and memory, are vulnerable to toxic insult, and what specific toxic substances, if any, are involved.

As a high priority, cognizant Federal agencies should bring investigators in LD together with specialists in measurement and test construction to develop diagnostic criteria and strategies, including assessments and provisions for periodic updating and revisions. The results should help close the gap between research, diagnosis, and remediation, and enable early identification of at-risk subtypes.

Preventing learning disabilities depends on discovering their cause, for primary prevention, and on improving capability for diagnosis and treatment, for secondary prevention. With these research activities still in an early stage of development, the most effective prevention research strategy at present is implementation of the recommendations on cause, diagnosis, and treatment.

I. MANDATE AND ACTIVITIES OF THE INTERAGENCY COMMITTEE ON LEARNING DISABILITIES

The Interagency Committee on Learning Disabilities (ICLD) was mandated by Section 9 of the Health Research Extension Act of 1985 (P.L. 99-158), enacted November 20, 1985. The mandate contains the following provisions:

(a) ESTABLISHMENT.--... the Director of the National Institutes of Health shall establish an Interagency Committee on Learning Disabilities to review and assess Federal research priorities, activities, and findings regarding learning disabilities (including central nervous system dysfunction in children).

(b) COMPOSITION.--The Committee shall be composed of such representatives as the Director may designate, but shall include representatives from the National Institute of Neurological and Communicative Disorders and Stroke, the National Institute of Child Health and Human Development, the National Institute of Allergy and Infectious Diseases, the National Eye Institute, the National Institute of Environmental Health Sciences, the Division of Research Resources of the National Institutes of Health, the Food and Drug Administration, the National Institute of Mental Health, and the Department of Education.

(c) REPORT.--Not later than 18 months after the date of enactment of this Act, the Committee shall report to the Congress on its activities under subsection (a) and shall include in the report--

  (1) the number of persons affected with learning disabilities and the demographic data which describes such persons;

  (2) a description of the current research findings on the cause, diagnosis, treatment, and prevention of learning disabilities; and

  (3) recommendations for legislation and administrative actions--

    (A) to increase the effectiveness of research on learning disabilities and to improve the dissemination of the findings of such research; and

    (B) respecting specific priorities for research in the cause, diagnosis, treatment, and prevention of learning disabilities.

(d) TERMINATION.--The Committee shall terminate 90 days after the date of the submission of the report under subsection (c).

Establishment of the Committee by the Director of the National Institutes of Health (NIH) was announced in the Federal Register on March 11, 1986. It included, in addition to the representatives named in the Act, representatives from the Centers for Disease Control, the Environmental Protection Agency, the Health Resources and Services Administration, and the Office of Human Development Services. Operational responsibility for the Committee and its activities was assigned to the National Institute of Child Health and Human Development (NICHD).

For the Committee to have the widest possible base of information about public concerns, a special effort was made to ascertain the identities of volunteer and professional organizations and non-Federal agencies known to have an interest in learning disabilities, to keep them informed of the Committee's activities, and to invite comments and suggestions from their leadership. Representatives of twelve of these organizations came on April 11, 1986, to the NIH campus for a meeting with representatives of the Committee to discuss their hopes for what the report might address and their suggestions for how the Committee might most effectively meet its mandate.

Formal activities of the Committee, in addition to eight meetings, included a Public Hearing on October 15 (announced in the Federal Register, August 7, 1986) on the NIH campus, and a National Conference on Learning Disabilities, January 12-13, 1987, also on the NIH campus. The Committee accepted with appreciation the offer of the Foundation for Children With Learning Disabilities to cosponsor the National Conference and assist with funding. Summaries of the presentations at the Public Hearing are provided in Chapter II of this report. The papers presented at the Conference reviewed the recent research literature on learning disabilities and formed the basis for the summaries of research accomplishments contained in Chapter V.

In addition to these activities, each Committee member surveyed the research activities and accomplishments of his/her agency; these reports are summarized in Chapter III.

Finally, taking into account all of the information gathered and the suggestions made, the Committee reached agreement on a set of conclusions and recommendations regarding learning disabilities research. These are set forth in Chapter VI.

II. VIEWS PRESENTED AT PUBLIC HEARING

A Public Hearing of the Interagency Committee on Learning Disabilities, announced in the August 7, 1986, Federal Register, was held on October 15 in Wilson Hall, Shannon Building, on the campus of the National Institutes of Health. The purpose of the hearing was to assist the Committee in its information-gathering activities for the preparation of this Report to Congress, by hearing from individuals and representatives of organizations, presentations of their views related to the Committee's mandate. In addition to the announcement in the Federal Register, the Committee sent letters to a wide range of individuals and non-Federal agencies, organizations, and associations, known to the Committee to have special interests and concerns about learning disabilities, inviting them to participate.

The hearing, which was chaired by the Director of the National Institute of Child Health and Human Development, National Institutes of Health, drew a capacity audience of about 100 persons. In addition to the statements of the presenters, time was allotted for questions and discussions with the Committee following each presentation, and for questions and comments originating in the audience.

In the course of the day, eighteen persons made scheduled presentations, and five persons were added to the agenda during the proceedings. Testimony was presented in behalf of seventeen professional and volunteer associations and organizations and non-Federal agencies, including the American Academy of Ophthalmology (representing 15,000 medical doctors), the Association for Children and Adults with Learning

Disabilities, the American Optometric Association, the American Speech-Language-Hearing Association (representing 50,000 speech-language pathologists and audiologists), the Council for Learning Disabilities, the Division for Learning Disabilities of the Council for Exceptional Children (representing more than 9,600 professionals), the Feingold Associations of the United States, the Institute for Training and Research in Auditory Conceptualization, the International Reading Association (representing more than 1,000 affiliate groups with total memberships of over of 250,000 reading professionals), the National Association of School Psychologists (representing 20,000 members), the National Information Center for Handicapped Children and Youth, the National Joint Committee on Learning Disabilities (representing constituent groups of more than 250,000 members), the Orton Dyslexia Society (representing 8,500 members), Tri-Services, Inc., the Parents of Gifted/Learning Disabled Children, and the Woodrow Wilson Rehabilitation Center, Virginia. The Committee also received statements from persons unable to attend the hearing.

The testimony presented at the hearing is summarized below.

Mrs. Laura Beard, who spoke as a private citizen, summarized her and her husband's frustrations in "struggling to obtain" in the public school system an appropriate education for their two learning disabled sons, who were later enrolled in private schools. She suggested that tests are needed that are more effective in identifying specific learning disabilities and pointing the way to remediation; that schools should have lists available of experienced advocates to provide emotional support for parents who believe or suspect that their children might be learning disabled; and that financial aid should be available to parents who have found private schools that are more effective in educating their LD children.

Drs. M. Elise Blankenship and Jean E. Lokerson (Associate Professors, School of Education, Virginia Commonwealth University) provided a historical overview highlighting the interrelated influence of both medicine and education on the emergence of learning disabilities as an identifiable category of disorders. They emphasized that LD is highly complex, with each individual's difficulties varying in both severity and extent. Unlike most handicapping conditions and many medical problems, LD is often difficult to observe or measure. Some students may not show LD in classrooms where the structure, teaching style, or curriculum matches a given set of abilities. In such cases, students may compensate or may subsequently adopt vocations that minimize demands on their weak areas. As a result of such factors, demographic data and prevalence estimates are misleading. They recommended the development of a model for reporting demographic and prevalence data that would take into account the influences of environment, definition, and program continuum in LD; continuation of efforts to clarify issues surrounding definition and program continuum in learning disabilities, with an emphasis on broadly based participation by education, medicine, and related disciplines; support of research from broad perspectives and across multiple disciplines for prevention, diagnosis, and treatment; and the creation of a mechanism to disseminate the wide range of diverse ideas, research studies, and programmatic innovations that develop within the various separate, yet related disciplines.

Ms. Cindy Brandt (Copresident, Parents of Gifted/Learning Disabled Children) defined gifted LD children as "individuals who are highly intelligent, creative, or talented but with one or more functions impeded." In some, their gifts are acknowledged while their LD goes unrecognized, and they are often called lazy. In others, the LD interferes with the recognition of their giftedness. A third category involves children whose exceptionalities mask each other. They use ingenious coping skills to hide their real difficulties until it is too late for simple early intervention, and the frustrations of coping surface as emotional or behavioral problems. There is a great need for research into identification, diagnosis, and effective programming and resources for educators. Because in most public schools these children fall into the void between the programs for the gifted and the programs for the learning disabled, experts have called them "the most misjudged, misunderstood, and neglected segment of the student population," she concluded.

Dr. Stan Dublinske (Director, State and Regulatory Policy Division, American Speech-Language-Hearing Association) urged the Interagency Committee on Learning Disabilities to look at LD not as a homogeneous diagnostic category but as a convenient generic term for a group of numerous disorders that make up the category of LD. Up to 80 percent of children and youth identified as demonstrating a learning disability, he stated, have language disorders. Research on the cause of LD should focus on the subgroup of disorders that manifest themselves as LD. Research should be conducted on the types, characteristics, and changing manifestations of LD during the lifespan of LD persons; relationships between LD and psychosocial maladjustments, including substance abuse, depression, and suicide; interactions between linguistic and perceptual processes; impact of early childhood language disorders on the later development of academic skills; methods for the remediation and education of individuals with LD; and indices of early behavior that best predict or correlate with later academic learning and personal and social adjustment.

Dr. Dublinske made the following recommendations for legislative and administrative actions to increase the effectiveness of research and to improve the dissemination of research findings: Continuation of the Interagency Committee on Learning Disabilities as a coordinating group for LD research and information dissemination; development of a five- or ten-year research plan that would ensure a coordinated effort by all Government agencies funding LD research, with requests to Congress for the funds needed for implementing the plan; and series of reports on research progress.

Mr. Kevin P. Dwyer (National Association of School Psychologists [NASP]) made available to the Interagency Committee the NASP Position Statement on Advocacy for Appropriate Educational Services for All Children. According to Mr. Dwyer, the label "handicapped" is not benign and can cause a child to be placed in an educational program that is unsuited to the special needs of the child. In addition, much of today's LD research is inadequate because the samples are often contaminated by children who are not LD. He recommended that the Interagency Committee direct research to examinations of the systemic problems that cause learning failures and to identification of exemplary programs that reduce such failures; develop research that clearly defines learning disabilities, using consistent criteria, and disseminates the criteria to researchers in the field so that comparative studies can be undertaken; and conduct longitudinal research on young children at high risk for LD to test the accuracy of high-risk predictors and to describe the effect of good regular instruction and realistic developmental expectations on children who appear to be LD.

Ms. Anne Flannigan (Executive Director, Orton Dyslexia Society) requested the Committee to recommend that Congress make funding available for clear, consistent, and readable guidelines about dyslexia, which would be given to parents in all educational systems. The guidelines would enhance parents' awareness of this difficulty and possibly save teachers from having to teach reading to high school students who have never been diagnosed, or had the benefit of early intervention. The educational system should provide a sequence of diagnostic teaching before the labeling and remedial process begins, she urged.

Dr. Jeannette E. Fleischner (Chair, National Joint Committee on Learning Disabilities [NJCLD]) briefed the Interagency Committee on the member organizations and on the history of the NJCLD, and stated that the purpose of the NJCLD is to facilitate communication and cooperation among its organizations, to provide an interdisciplinary forum for the review of issues for educational and governmental agencies, and to act as a resource for those agencies and other interested groups. She stated that the NJCLD has defined learning disabilities as "a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, reading, speaking, writing, reasoning, or mathematical abilities. The disorders are intrinsic to the individual and are presumed due to central nervous system dysfunction." This definition, according to Dr. Fleischner, differs from that incorporated into P.L. 94-142 in its emphasis that learning disabilities can affect individuals throughout life, that the term is generic and subsumes a heterogeneous group of disorders, that the disorders are intrinsic, and that the manifestation of disability may appear in individuals who are otherwise handicapped, such as those with hearing or vision impairment. She urged the Committee to adopt this revised definition. The belief of the NJCLD, on the basis of the clinical practice of its membership and of available research data, is that between 3 percent and 5 percent of the U.S. population is affected with a learning disability. She provided the Interagency Committee with six NJCLD position papers and conveyed the willingness of the NJCLD to assist the Interagency Committee in any way.

Ms. Anne Fleming (Past-President, Association for Children and Adults with Learning Disabilities [ACLD, Inc.]) observed that neurosciences research has entered the LD field and should be coordinated with LD research in education and psychology. She applauded the request for applications, issued jointly by the National Institute of Neurological and Communicative Disorders and Stroke and the National Institute of Mental Health, for a Multidisciplinary Research Center for the Study of the Neurological Basis of Disorders of Language, Behavior, and Learning During Infancy and Early Childhood; and she urged close, continued cooperation among agencies and institutes in finding the causes, diagnosis, treatment, and prevention of learning disabilities. Ms. Fleming indicated that the ACLD's definition of learning disabilities differs from the NJCLD's definition because the ACLD felt that the latter was limited to the school-age children. The NJCLD definition therefore does not really satisfy the needs of adults with learning disabilities.

Dr. Thomas Frey presented the Statement of Policy of the American Academy of Ophthalmology Concerning Learning Disabilities, Dyslexia, and Vision--namely, that ophthalmologists are a part of the interdisciplinary team dealing with learning disabled children, and that children suspected of LD should have early ocular examinations and prompt treatment of ocular defects. Such an elimination of visual handicaps would better equip LD children to function in a learning environment.

Ms. Robin Hawks (Director, Research and Demonstration Project for Improving Vocational Rehabilitation of Learning Disabled Adults, Woodrow Wilson Rehabilitation Center, Virginia) discussed the emotional and social problems of LD adults. Results of a six-state survey show that talking or acting before thinking is the number one problem of LD adults (47 percent); dependence on others follows (36 percent). Personal problems are: feeling frustrated (61 percent), poor self-confidence (49 percent), and controlling emotions and temper (31 percent). To understand the social and emotional complexity of LD individuals, evaluators should include assessment of social skills, initiative and self-direction, self-control and impulsivity, and self-esteem. Great care is needed in making a diagnosis of LD, and many psychologists are not trained in this area. Researchers need a network of information exchange in order to build on each other's knowledge.

Ms. Jane Hersey (Executive Director, Feingold Associations of the United States) quoted Ben Feingold, M.D.: "Any compound in existence, natural or synthetic, has the capacity to induce an adverse reaction in an individual with the appropriate genetic profile." She then described the Feingold Program, which eliminates synthetic colors and flavors, the antioxidants BHA, BHT, and TBHQ, and which temporarily removes certain foods with naturally-occurring salicylates.

Dr. Roselmina Indrisano (President, International Reading Association) recommended that the team responsible for diagnosis, planning, and education programming for LD students should include, along with subject matter specialists and special educators, a professional with competence, knowledge, and experience in the area of an individual student's major disability; that the professional coordinate all aspects of the student's educational plan, to assure a consistent and integrated approach to intervention based on each student's needs; and that the student's classroom teacher participate actively on the team. For future research, which should be multidisciplinary and include the expertise of psychologists and physicians, better data on issues of description are needed. In addition, research should include evaluation of planning and intervention approaches.

Dr. Delores M. John (Director, National Information Center for Handicapped Children and Youth) addressed the need for research and policy considerations in issues central to the educational and social development of LD persons. She stated that in view of the costly procedures for referral of "very-difficult-to-teach" students to LD programs with highly questionable results, support should be given to pre-referral modifications and functional assessment. The question of LD identification and subgrouping should be addressed. She also indicated that there is a major need for further research and for improved programs in the areas of child and family developmental growth and of social skills and behavior of LD children. Vocational transition research and model program implementation should also have a priority.

Ms. Mary Kistler (President, Feingold Associations of the United States) referred to the 1982 NIH Consensus Development Conference on Hyperactivity, which "accepted dietary management of childhood hyperactivity as an appropriate modality" for some children. She recommended the testing of food additives for behavioral toxicity, especially among infants and young children; full disclosure labeling on foods, beverages, and medications; and further research in the biosciences on diet and hyperactivity.

Dr. James E. Leigh (Past-President, Council for Learning Disabilities [CLD]) reviewed a number of problems associated with definitions of terms. He stated that the foundation for the conceptual definition of learning disabilities incorporated in P.L. 94-142 is almost two decades old. This old definition should be replaced by the definition adopted in 1981 by the National Joint Committee on Learning Disabilities, he said, which is less age-restrictive and does not contain language which can be interpreted to mean that a learning disability cannot occur in conjunction with other handicapping conditions. He also urged that students whose learning problems are primarily attributable to non-LD handicapping conditions or to adverse environmental influences, and in particular, nonhandicapped students who are low achievers or underachievers not be placed in LD programs. He requested that appropriate Government agencies conduct a public awareness campaign to counter the effects of inaccurate information as well as the inappropriate diagnostic and treatment practices and ethically questionable conduct to which some families of individuals with LD are subjected.

Ms. Patricia C. Lindamood (Executive Director, Institute for Training and Research in Auditory Conceptualization) noted that despite individual differences, biomedical researchers have identified factors that are basic to the life process. She suggested that the learning process may also have basic factors and that there is a need to search for and recognize them.

Dr. Jeanne McRae McCarthy (Chair, Advisory Committee, Division of Learning Disabilities of the Council for Exceptional Children) recommended development and use of a "shared attribute" model of learning disabilities, leading to a taxonomy. She also suggested the need to distill from fragmented research on the biological basis of normal human learning a documentable theory of learning, into which accumulated knowledge about nonlearning could be retrofitted. She encouraged formulation of a comprehensive plan of multidisciplinary research and evaluation focused on improving the educational experience of LD students, and urged that research on early identification of children at risk, intervention, and prevention be a Federal priority.

She stated that the frequency of LD is between 3 percent and 7 percent, depending on the age of the child, with preschool children showing the lower proportion. Operationally, however, many school districts are combining "slow learners" with LD students, raising the figure served in LD programs to over 10 percent, she said.

Ms. Claire D. Nissenbaum (Codirector, Tri-Services, Inc.) characterized Tri-Services as a multiprogram agency that specializes in the educational habilitation of mainstreamed students with specific learning disabilities. She stated her belief that learning disabilities are the consequence of neurophysiological deficits which themselves are consequences of a definable, diagnosable syndrome, and should not be called brain damage. They affect all areas of academic and social functioning so that reading problems are only part of the consequences.

She perceives that the incidence of LD is 7 percent to 10 percent or higher; the category is overidentified in most schools, but many LD children are not being identified. As research priorities, she suggested adoption of a standard uniform definition of LD for research purposes; development of methods for valid and reliable differential diagnosis; and research on effective clinical training of clinical psychologists, educational diagnosticians, speech-language pathologists, and other evaluators. She also encouraged research on the relationship between effective educational treatment and teacher personality traits; and long-range research on the incidence of LD and language delays, disorders, or difficulties in preschool children, through college. Other research recommendations included studies of the obstetrical histories of mothers of LD children; and comparative studies of children from groups that abstain from specific foods and beverages as compared to matched samples of children of nonabstinent families.

Mr. John Pietz introduced himself as someone who is probably gifted/learning disabled. He spoke of his graduating from college at the age of 41 and of his having a son with signs of the same problem. After describing his own difficulties, he encouraged research on LD and suggested that he might be a suitable subject for scientific study.

Ms. Lavonne Radonovich (President, Frederick County [Maryland] Association for Children with Learning Disabilities), who identified herself as an educator and a parent of identical twin boys with learning disabilities, discussed the stress experienced by the families of LD children, the low esteem the children feel, and the frustrations of dealing with school systems. She called for mandatory psychological services to LD children and their families as soon as the disabilities are identified; prohibiting grade retention of LD children; requiring school districts to develop remediation programs; and training specialists in the latest educational techniques to meet the educational needs of each LD child. She encouraged research to obtain data about the school dropout rate of LD children and their appearances in family and juvenile courts.

Ms. Suzanne Ripley, the mother of two severely learning disabled sons, spoke of the frustrations of parents with LD children. She urged more medical and educational research, studies and replication of successful school programs, exploration and refinement of theories that are working, and teacher and parent training.

Mr. and Mrs. Allan M. Shapiro (Copresidents, Montgomery County Association for Children and Adults with Learning Disabilities), who are parents of three learning disabled children, described the confusion and frustrations of parents. Neighbors, friends, and members of the medical profession can identify with physical disabilities, but for those with the hidden handicap of LD, there are few supports and there is even less understanding. Although much information about LD exists, it is not coordinated and is often conflicting. Parents need to know what questions to ask, and doctors and educators need to know what to look for. Mr. Shapiro recommended a national data base containing all relevant collected data, including reference information and names of individuals and places to turn to.

Dr. Harold Solan (Director, Learning Disabilities Unit, State College of Optometry, State University of New York), who presented the position of the American Optometric Association, stated that the optometrist does not directly treat a learning disability but is a member of an interdisciplinary treatment team and focuses on the visual problems of learning disabled individuals. In some individuals, visual problems may be a primary cause of a learning disability, but in many instances they are contributory, he said. After giving an overview of specific visual problems that can affect a person's ability to read and write, he recommended research to establish and define the relationship of refractive errors and binocular, accommodative, oculomotor and perceptual dysfunctions to reading and learning disorders at different age levels; and carefully matched and controlled intervention studies of the effect of correcting and/or treating these ocular problems on educational performance at different age and performance levels.

Dr. Eleanor C. Westhead (Associate Professor and Director, Learning Needs and Evaluation Center, University of Virginia) described the differing definitions of learning disability in the last 40 years, and decried the deemphasis on medical aspects of the condition. She recommended a longitudinal study of children identified as high risk and of students identified as LD in elementary school, or as late as in high school or college.

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Two persons who did not present testimony at the hearing submitted statements for the record, which are summarized below.

Mr. Norman G. DeLisle, Jr. (Area Supervisor, Michigan Protection and Advocacy Service), noted that researchers in the past have used such narrow definitions of learning disabilities that the literature contains huge amounts of very specific but useless information, and the problem is "defined away"; for research purposes, the definition of LD should reflect the full range of information processing problems and deficit levels.

Research should focus on using an information processing model heavily dependent on neurophysiological concepts. Research on diagnosis should focus on the ability of currently available batteries and tests, especially in the neuropsychological area, to create a diagnostic information base that is sufficient to allow adequate intervention. Treatment research should focus on the results of multidimensional treatment approaches.

Dr. Marsel Mesulam (Director, Division of Neuroscience and Behavioral Neurology, Beth Israel Hospital, Boston) noted that there are many types of learning disabilities and that some types are more difficult to recognize than others. In typical dyslexia, for instance, other cognitive and behavioral functions are intact, if not superior. Interpersonal skills, judgment, foresight, and a sense of conscience are incorporated in a fashion quite analogous to linguistic and mathematical skills. His research has led to a finding that developmental injury to the right side of the brain can result in a type of learning disability characterized by ineffective interpersonal skills and extreme shyness. His current research points out that some individuals who seem to lead a sociopathic life or to have no judgment or conscience show evidence of early injury to the frontal lobes of the brain. It is therefore critical to realize that major behavioral disorders may be rooted in special types of learning disabilities, he said. An awareness of this possibility is likely to have a major impact on the prevention and management of these conditions.

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OBSERVATIONS BY THE INTERAGENCY COMMITTEE ON LEARNING DISABILITIES

The Committee was impressed with the broad spectrum of interests and concerns expressed in the testimony, ranging from findings and needs in basic research on learning disabilities--to accounts of experiences in clinical practice, rehabilitation, and remediation--to problems and needs in delivery and quality of services to affected persons. The Committee is grateful to those who took the time and the effort to make presentations, and feels that it heard representations on behalf of over one million people whose families have members with learning disabilities or whose professions are focused on learning disabilities research or on service to persons affected by learning disabilities. The Public Hearing gave the Committee an early sense of the burden and importance of its Congressional mandate.

III. SURVEY OF FEDERAL AGENCY RESEARCH PRIORITIES, ACTIVITIES, AND FINDINGS REGARDING LEARNING DISABILITIES

Public Law 99-158 required the Interagency Committee on Learning Disabilities to review and assess Federal research priorities, activities, and findings regarding learning disabilities.

It became apparent in discussions at Committee meetings that two broad categories of Federal activities could be identified: (1) learning disabilities--specific, and (2) learning disabilities--related. The Committee then agreed that each member agency should prepare for inclusion in this Report a survey of its programs and a description of research opportunities in the area of learning disabilities, with particular reference to "specific" and "related" concerns. Each agency would also provide budgetary information on its expenditures for Fiscal Years 1985 and 1986 and projections for 1987. Agency survey results are reported below. Each survey provides a description of the agency's mission, a summary of its activities related to learning disabilities, a description of its program highlights and accomplishments, a statement of opportunities and needs, and budget data on learning disability expenditures.

A. DIVISION OF RESEARCH RESOURCES

NATIONAL INSTITUTES OF HEALTH

The Division of Research Resources (DRR) of the National Institutes of Health supports a variety of multicategorical interdisciplinary research resources essential to biomedical research. A large number of investigators use the resources in several research disciplines to enhance their own effectiveness and that of their institutions in responding to the overall missions of the National Institutes of Health.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The DRR comprises five major programs: General Clinical Research Centers, Biomedical Research Technology, Minority Biomedical Research Support, Biomedical Research Support, and Animal Resources. All of these programs support research in learning disabilities.

The General Clinical Research Centers program provides resource support for several projects that include a variety of areas within learning disabilities, such as memory, cognition, language disorders, and attention deficit disorder.

By providing research scientists with access to appropriate and effective use of animals for study, the Animal Resources Program supports learning disabilities research that focuses on the influence of low birth weight and of rearing environment on cognitive performance.

The Biomedical Research Support program complements existing NIH-supported research, and therefore, reflects the broad range of learning disabilities research supported by the NIH. Studies include speech pathologies and language disorders, memory dysfunction, and attention deficit disorder. Other research includes adult and child dyslexia, cognitive development, and auditory function in learning disabled children.

The Biomedical Research Technology program emphasizes the application of the physical, mathematical, engineering, and computer sciences to biomedical research problems. The program involves funding resources that adapt existing technology to serve biomedical needs or that develop new instruments to address special problems. Current studies include metabolic models of cognitive dysfunction and handedness in learning disabilities.

The Minority Biomedical Research Support program provides support to enhance the development of minority faculty, students, and institutions in biomedical research. Studies in this program include learning problems and memory disorders.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

Data from studies to objectively evaluate cognitive processes in apes have compared well with those obtained from learning disabled children. Numerous behavioral studies of nonrepresentation imitation, number concepts, same/different discriminations, color attributes, and comprehension of verbal English have been performed.

Researchers have begun to examine the neurobiological mechanisms in attention deficit disorder with use of a carefully integrated analytical program embodying two pivotal methodologies. The first is the incorporation of operationally defined diagnostic criteria. The second is the use of a pharmacologic probe (methylphenidate), designed to perturb central monoaminergic systems. Most recently, investigators have demonstrated the utility of employing such a pharmacological probe in combination with a unique monoamine oxidase inhibitor, debrisoquin. Preclinical studies in animals and investigations in humans have both confirmed the strong correlation between plasma and brain homovanillic acid (HVA), a major metabolite of dopamine during debrisoquin treatment. In addition, debrisoquin pretreatment significantly augments the sensitivity of plasma HVA as a reflection of changes in brain HVA induced by the pharmacological probe. Such findings support the belief that the small changes in brain HVA reflecting brain dopamine activity can be reliably measured as alterations in plasma HVA during combined treatment with methylphenidate and debrisoquin in children with attention deficit disorder.

NEEDS AND OPPORTUNITIES

The Division of Research Resources does not undertake program initiatives in specific scientific areas. It will continue to support research initiated by the categorical NIH institutes and other health and behavior research of interest to resource-supported investigators.

EXPENDITURES

Funding provided by the DRR for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.	$	(No.)
LD - Specific	261,708	*	183,303	*	192,000	*
LD - Related	1,272,824	*	1,497,511	*	1,730,000	*
LD Total	1,534,532	116*	1,680,814	125*	1,922,000	135*

* Resource grants support multidisciplinary research with only portions of a grant devoted to a specific scientific area such as learning disabilities. Therefore, a count of DRR grants is not comparable to a count of grants typically supported by other NIH components.

B. NATIONAL EYE INSTITUTE

The mission of the National Eye Institute (NEI) is to conduct, foster, and support basic and applied research, including clinical trials, related to the cause, natural history, prevention, diagnosis, and treatment of disorders of the eye and visual system, and in related fields (including visual impairment and its rehabilitation).

In human society, most information is acquired through the visual system. Uncorrected impairment of visual functioning can prevent the normal acquisition of information through this sensory modality and lead to difficulties in learning. While most definitions of learning disability explicitly exclude diagnosable vision disorders, there may be subtle abnormalities of binocular functioning, accommodation to close visual targets, or higher processing of visual information that interfere with the learning process. Detection of any such abnormalities and exclusion of more obvious vision problems at the earliest possible point in a child's development are crucial to the prevention of subsequent learning disabilities that might otherwise ensue.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The National Eye Institute has no program of research directly related to learning disabilities. However, there are active research programs devoted to developing better ways to detect visual processing deficits early in infancy or childhood, to understanding the development of accommodative mechanisms and their relationship to binocular functioning, and to understanding the normal development of eye movement control. Research on amblyopia (lazy eye) is also relevant to the problem of learning disabilities because of the high potential for misdiagnosis of children with this visual disorder.

The NEI supports research projects on the general neurobiology of vision and especially vision development. There are numerous projects on the neuroanatomical and neurophysiological mechanisms mediating the behavioral effects of visual deprivation or abnormal visual input, and studies of the basic control of eye movements or eye movement disorders.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

Undetected amblyopia can lead to misdiagnosis of dyslexia or other learning disabilities. It is therefore important to gain a clear understanding of the nature of the sensory defect, particularly as it is manifested in infants and young children. The most important investigations in amblyopia are research into the clinical condition of amblyopia, its detection at the earliest age possible, characterization of the various defects in vision subsumed under the rubric amblyopia, improvement of methods of evaluating vision in infants and young children to better assess progress in the treatment of amblyopia, and further research into the newly discovered mechanisms of the defect and distortions of spatial vision in amblyopic eyes.

A modification of the preferential looking technique (acuity cards) has given additional impetus to the search for screening techniques that can be used by clinicians or trained lay persons to detect the disorder. Comparisons of the results from use of acuity cards with those from more technologically oriented methods such as visual evoked potentials or the full preferential looking technique show general agreement. There may be some differences in their sensitivity for specific kinds of visual loss, however. Use of these techniques for assessing infant vision is already permitting evaluation of treatment outcomes in very young patients. For example, monocular grating acuity testing suggests that early surgery for removal of unilateral congenital cataract, followed by optical correction and occlusion therapy, results in relatively favorable long-term visual behavior but does not, even with good compliance, completely eliminate deprivation amblyopia.

Psychophysical studies are revealing basic differences in the spatial vision of strabismic and anisometropic amblyopes. Vernier acuity (the ability to detect very small offsets in the alignment of two line segments), for example, is affected more severely in strabismic amblyopes, giving rise to a hypothesis that strabismic amblyopic vision may be similar to vision in the normal periphery.

To screen for refractive errors in infants and young children, it is necessary to have some idea of the distribution of normal refractions. A number of studies using different methods have confirmed the existence of refractive errors in populations of infants in the United States. In addition, population samples of Chinese infants indicate that the genetic background of the infant may be important in determining whether or not the infant is ametropic (has an error of refraction in which parallel rays of light are not focused on the retina). New techniques for screening will enable large-scale detection of children at risk for developing amblyopia as well as poor vision from refractive errors. Photoretinoscopy is a particularly appealing screening technique that shows in a single photograph the reflex of light from the cornea and retina of both eyes simultaneously. Although the optical basis of the technique has now been explicated, research to evaluate its usefulness has really just begun.

Accurate accommodation (the involuntary change in shape of the lens to focus images at varying distances onto the retina) is essential for seeing a clear image of the world, and accurate convergence of images from the two eyes is necessary for clear binocular vision. Errors in either of these control loops can destroy clear vision, making acquisition of information from the printed page impossible. Both accommodation and vergence have been areas of active research in infants and adult humans. It has been shown in infants that vergence and accommodation are uncoupled in the absence of patterned stimuli. In adults, it has been found that focusing in low light conditions and vergence are differentially affected by near work, implying that they are determined by separate mechanisms. In a longitudinal study of variations of accommodation, vergence, and refractive error in college students, measures of vergence remained fairly constant over years, while both dark focus and refractive error shifted progressively toward increased myopia. Following a 3-month summer vacation, both measures showed an equivalent regression toward less myopia. These findings are relevant to the hypothesis that variations of tonic accommodation are a precursor to the development of work-related myopia and possibly to asthenopia (visual discomfort) associated with near work, including reading.

OPPORTUNITIES AND NEEDS

It is imperative that techniques for assessing the integrity of the visual system in children with suspected learning disabilities be both sensitive to the existence of an abnormality and specific to the dysfunction being assessed. There is thus a clear need for more research on noninvasive techniques for testing vision in infants and young children. Better means of assessing the degree of binocular functioning and oculomotor control in children must be developed. Further research on the development of accommodation and the sensory and oculomotor consequences of abnormalities in accommodation is also necessary. On the clinical side, better understanding of the range of deficits in amblyopia, some of which may be quite subtle and lead to problems in diagnosing learning disabilities, is a high priority. There is also a clear need for a well-designed randomized controlled clinical trial of vision therapy in dyslexic children with defined abnormalities of visual information processing.

EXPENDITURES

Funding provided by the NEI for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.	$	(No.)
LD - Specific	--		--		--	
LD - Related	3,223,999	(37)	2,900,389	(29)	3,374,000	(37)
LD Total	3,223,999	(37)	2,900,389	(29)	3,374,000	(37)

Note: Excluded are general basic neurobiological, neuroanatomical, and neurophysiological projects, and basic studies of eye movement control.

C. NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES

The National Institute of Allergy and Infectious Diseases (NIAID) conducts and supports basic and clinical research and research training activities in microbiology, infectious diseases, immunology, and disorders of the immune system, including asthma and allergies. These endeavors are directed toward the prevention, diagnosis, treatment, and eventual eradication of infectious, allergic, and immunologic disease. Although the NIAID does not support research projects that deal directly with learning disabilities, it funds and conducts related research on a number of diseases and disorders that impact on the development of learning disabilities. Successful classroom functioning, for instance, depends in great part on auditory-verbal and visual-motor sensory modalities; therefore, an infection or an immune disorder that interferes with the normal development of the fetus, neonate, or child may be a key factor in the development of future learning disabilities.

ACTIVITIES RELATED TO LEARNING DISABILITIES

Immune Deficiency Disease

The fetus in utero is in a sterile environment and produces only small amounts of immunoglobulins (IgM, IgG, and IgA). As a result, the neonate's immunity to different diseases depends largely on the kinds of IgG antibodies received from the mother via placental transfer. Research on the prenatal immune system may be important for understanding learning disabilities because of evidence in animals that prenatal immune disorders can affect brain development and result in behavior comparable to what is observed in learning disabled children.

Infectious Diseases

Sexually transmitted diseases (STDs) remain a serious problem in the United States and throughout the world, and the NIAID is the major source of support by the Federal Government for STD research. The medical implications of STDs for the fetus and neonate are serious and include abnormal development, dysfunction, and structural damage. Genital herpes is widespread, particularly among young adults of childbearing age. The number of cases of syphilis and gonorrhea has declined in the United States but continues to increase in two-thirds of the world. In addition to these STDs, the NIAID supports research on many other genital infections, including chlamydia, cytomegalovirus, and group B streptococcus.

Intrauterine infections, not all of which are sexually transmitted, also pose a potential threat to the fetus and neonate. Pregnant women infected with certain viruses, bacteria, or parasites may transmit them to the unborn or newborn babies. In some cases, intrauterine and perinatal infections have no effect on the unborn child; however, in other instances, they may result in death or in serious impairment such as mental retardation. A reduction in the incidence of rubella syndrome has occurred since the introduction of a vaccine in 1970; however, rubella has not been eliminated. A common but potentially devastating intrauterine infection is toxoplasmosis, a disease caused by the parasite _Toxoplasma_ _gondii_, which can be transmitted in the feces of an infected cat or in uncooked meat. Approximately 4,500 infants are born annually in the United States with congenital toxoplasmosis. Clinically recognizable disease affecting the central nervous system (often blindness) occurs in about one-fourth of these infants, and a significant number of asymptomatic infants develop serious sequelae late in life. Research supported by NIAID is directed toward finding better ways to diagnose, prevent, and treat infections that can occur during pregnancy and severely affect normal development.

Postnatal infections vary in severity. A number of central nervous system infections in the neonate and child can result in death or severe incapacitation. Meningitis, an inflammation of the meninges of the brain or spinal cord, may occur as the result of a bacterial, viral, fungal, or parasitic infection. Bacterial meningitis is a major cause of death, mental retardation, or learning problems in children. In newborns, group B streptococci and gram-negative bacilli, especially *Escherichia coli*, are the major pathogens. The organisms responsible for bacterial meningitis in infants and older children are *Hemophilus influenzae* type b, *Neisseria meningitidis*, and *Streptococcus pneumoniae*. *Staphylococcus aureus* and *Listeria monocytogenes* have also been implicated as causes. Viral meningitis may be caused by arbo-, polio-, echo-coxsackie, and herpes viruses. Better diagnostic, therapeutic, and preventive methods are under study.

Acute otitis media, a bacterial or viral infection of the middle ear, usually secondary to an upper respiratory infection, is common in the young child. In the neonate, the causative agents are primarily *Escherichia coli* and *Staphylococcus aureus*. In older infants and young children, it is more likely to be caused by *Streptococcus pneumoniae*, *Hemophilus influenzae*, or beta-hemolytic streptococci. Otitis media is one of the most frequent infections of the infant and young child with the possibility of the development of hearing disorders and subsequent learning disabilities.

Studies are continuing on the development and clinical testing of vaccines. A multivalent pneumococcal polysaccharide vaccine has already been licensed for use in adults. Investigations are under way on an effective and practical vaccination against the pneumococcus in children and adults who do not respond to the available vaccine. Aside from infections, middle ear disease can also arise from allergic problems. Studies are being supported by the NIAID that focus on immune mechanisms of middle ear disease.

The prevention of infectious diseases and their complications or sequelae is accomplished through six major approaches: immunization with vaccines, immunoprophylaxis with specific immune globulins, chemoprophylaxis, environmental control, interruption of spread by control of vectors, and interruption of spread by prompt diagnosis and early treatment of index cases. Of these approaches, immunization is one of the most effective. Accordingly, in 1981, the NIAID initiated a Program for the Accelerated Development of New Vaccines to exploit recent advances in knowledge of the physiology of the immune system, the molecular and cellular biology of infectious agents, and the development of recombinant DNA and cell-fusion technologies that greatly simplify the identification and purification of protective antigens. The NIAID also has an extensive program to develop and test antiviral drugs for a number of diseases. In addition, a number of NIAID-supported studies focus on the mechanisms of resistance to infection. Improved understanding of the mechanisms responsible for the host's response may permit the eventual pharmacologic modulation of that response.

Genital Herpes

Babies born to mothers with herpes virus in the birth canal are at risk of death or severe damage to the central nervous system, leading to learning problems or mental retardation. The threat of transmission to the neonate is so great that the recognition of herpes vaginal infection during the last month of pregnancy is sufficient to warrant delivery by cesarean section. The NIAID has supported studies of the amount of virus shed by pregnant women with a history of recurrent herpes and by those who developed a first episode during pregnancy. The investigators found that women with recurrent herpes shed large amounts of virus during recognizable outbreaks and small amounts when there were no symptoms. Women who developed typically fulminant "true primary" infections during early pregnancy experienced few or no subsequent episodes of overt disease during the remainder of their pregnancies, but even in the absence of clinical symptoms, they shed large amounts of virus and were more apt to begin labor earlier and deliver lower birth weight infants than women with recurrent herpes. The investigators stress that more preventive measures should be directed toward the small group of women who develop primary infections during pregnancy.

Although no cure for genital herpes is available, oral acyclovir has been approved for treatment. The drug was proven effective in extensive NIAID-supported clinical trials. It reduces both the severity of genital herpes in adults and the frequency of recurrence if taken continuously. Unfortunately, treatment does not lead to a permanent cure. On the basis of recent studies, researchers report evidence for the feasibility of developing effective vaccines.

Cytomegalovirus

Another member of the herpes virus family, cytomegalovirus (CMV), is the most common cause of congenital infection. It affects 1 percent to 2 percent of babies born in the United States and is the leading known cause of deafness. Several NIAID-funded studies support the hypothesis that CMV is sexually transmitted. In these studies, it has been observed that young CMV-infected women who also have chlamydial infections shed more virus and presumably were more likely to transmit CMV infection. The evidence that women of childbearing age may acquire primary CMV infection by sexual contact has important public health consequences because primary infection during pregnancy is likely to cause serious congenital infection. CMV can be transmitted from mother to baby before birth, during birth via the genital tract, or after birth through breast milk. Although CMV-infected infants and adults usually show no symptoms, about one of every ten infected babies is born with symptoms, such as jaundice, enlarged liver and spleen, and brain abnormalities. CMV contributes at least 6,000 children a year to the ranks of retarded, disabled citizens, and many of those who are less severely affected have learning problems. NIAID-supported scientists are also studying the prevalence of CMV infection in pregnant women to try to determine who is at risk for primary (first) or recurrent CMV infection during pregnancy. In addition, research is being done on the biology of the virus, detection of infection, pathogenetic mechanisms, and vaccine development.

Group B Streptococci

Group B streptococci (GBS) infection is the most common cause of fatal bacterial infections in the newborn, causing several thousand infant deaths each year. As many as one-half of the babies surviving GBS infection can suffer severe consequences such as blindness, deafness, cerebral palsy, and intellectual deficits ranging from learning problems to mental retardation. GBS can be transmitted to babies at birth if their mothers are harboring the bacteria in the genital tract at the time of delivery. The mothers usually have no symptoms of GBS infection, and some women do not produce antibodies that would protect their newborn infants. Recognition and treatment of infection during pregnancy is an important aspect of preventing neonatal transmission; however, immunization against infection of sexually active females of childbearing age may be the best approach to prevention. NIAID-supported scientists are working on developing a vaccine for pregnant women who lack GBS antibodies to prevent neonatal GBS disease. However, because some women do not seem to produce antibodies to GBS even after immunization, researchers are investigating the use of immune serum globulin, a blood product containing human antibodies to GBS, during pregnancy to confer immediate immunity to the fetus. Other investigators have developed a rat model of newborn GBS infection in which infection is acquired orally, as it is thought to be in humans. Administration of a modified oral vaccine appears to reduce GBS gastrointestinal colonization and systemic disease significantly in the animal model.

Toxoplasmosis

Like CMV infection, toxoplasmosis causes few if any symptoms in adults and may not cause symptoms in a congenitally infected infant at birth.

However, several months to years later, the child may develop blindness, epilepsy, mental retardation, learning problems, or other severe disorders. These consequences can often be avoided, however, if treatment is started promptly after birth. An NIAID-investigator has found a method for studying and diagnosing congenital infections such as toxoplasmosis in the newborn. A technique called protein blotting can be used to produce patterns of antibodies when these react with antigens or markers of the Toxoplasma parasite. This technique can help identify newborns in need of treatment to prevent serious sequelae of toxoplasmosis.

Meningitis

Much NIAID research has been devoted to the development of new and improved vaccines against childhood diseases such as meningitis. The second most common cause of serious childhood meningitis is Hemophilus influenzae type b (Hib). Although antibiotic treatment has reduced mortality rates, survivors suffer neurological sequelae such as mental retardation, learning problems, deafness, blindness, hydrocephalus, and epilepsy. Recently, a Hib vaccine made from the purified polysaccharide coat of the bacterium was approved for use in children 2 years of age and older. To date, vaccines developed to prevent Hib have not been effective in producing protective antibodies in younger children, who have the highest incidence of the disease. However, a new generation of Hib vaccines has been developed that show promise of being effective in children of all ages. These conjugate vaccines combine the Hib capsular polysaccharide to a protein carrier, which enhances the individual's immune response to Hib. Trials are under way to test the efficacy of these vaccines.

Diet and Hyperactivity

Attention has been focused on the alleged relationship between food allergy and hyperactivity/attention deficit disorder, following a report in 1973 by Feingold of clinical observations of the benefit of a diet free of salicylates and food additives in controlling hyperactivity. In January 1982 a Consensus Development Conference sponsored by the NIAID and cosponsored by the NICHD was held at the NIH to seek positions on issues involving defined diets and childhood hyperactivity. The panel identified a number of critical gaps in the knowledge that affects interpretation of the results of dietary intervention in the management of hyperactivity syndrome. The deficiencies the panel cited include nonuniform diagnostic standards and inadequate information regarding the natural history of this syndrome, lack of availability of optimal measurement instruments (behavioral, cognitive, and others), and other significant limitations in the research study designs employed. In addition, the panel noted that the full potential of animal and in vitro studies for generating relevant biologic information has not been realized. It was recommended that further research be conducted in each of these areas in an effort to produce meaningful results regarding the potential benefits of dietary management of hyperactivity. The NIAID is not currently supporting any research in this area. If a correlation exists between diet and hyperactivity, it is not thought to be based on an immune mechanism.

OPPORTUNITIES AND NEEDS

Despite major research advances, immunologic, allergic, and infectious diseases remain high among the Nation's great public health problems. A great many of these diseases have a tremendous impact on the development of learning disabilities. Future advances in these areas depend on continued basic research into the identity of etiologic agents; studies of the epidemiology and natural history of diseases; maintenance of repositories for research resources; development of rapid, inexpensive, and sensitive diagnostic methods for early detection; exploration of immunologic abnormalities of disease states; development and testing of therapeutic agents; and development and testing of vaccines for the prevention of infectious diseases and their possible sequelae. The NIAID has a strong commitment to research in these areas and will continue its efforts to resolve the health problems, falling within the Institute's purview, which generally contribute to the development of learning disabilities.

EXPENDITURES

Funding provided by the NIAID for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	--		--		--	
LD-Related	22,913,125	(168)	24,734,882	(183)	26,894,000	(192)
LD-Total	22,913,125	(168)	24,734,882	(183)	26,894,000	(192)

D. NATIONAL INSTITUTE OF CHILD HEALTH AND HUMAN DEVELOPMENT

The mission of the National Institute of Child Health and Human Development (NICHD) is to help families have healthy children at the time they are wanted, to prevent disease and disability among children, to foster normal development early in life, and to ensure that every child has the opportunity to fulfill his or her potential for a healthy and productive adulthood. In pursuit of its mission, the NICHD conducts and supports biomedical and behavioral research programs focused on the processes that determine the health of children, adults, families, and populations. It has responsibility for research that addresses the prevention of disease and disability, and thus for improving the health and functioning level of the future adult population of the United States. The Institute supports a major research program on learning disabilities. Such disabilities are a major barrier to the development of many persons, which prevents them from reaching a healthy and fully productive adulthood.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The NICHD has identified learning disabilities as one of several research opportunities to receive major attention. At present, the Institute's research related to learning disabilities covers a wide spectrum of studies, ranging from the learning and cognitive processes, language development and reading, to specific learning disabilities, dyslexia, and social skills deficits. These NICHD-supported research efforts focus on basic developmental biology, behavioral biology, learning and cognition, perception, and memory as they relate to normal children and adolescents and to those with learning disabilities. Studies of the learning processes in nondisabled children serve as a standard against which the difficulties in the acquisition of academic skills by children with disabilities can be measured.

Other NICHD research in this area includes the long-term consequences of learning disabilities, the role of computers in the diagnosis and treatment of learning disabilities, and the use of molecular biology techniques and quantitative genetic methods to investigate the role of heredity in several types of learning disabilities. Studies of brain activity and brain structure are also in progress to determine their potential as methods for diagnosing learning disabilities.

Further NICHD-supported research is investigating the ways in which psychological processes such as memory, learning, attention, perception, and cognition are affected by individual differences in genetics, nutrition, and diseases. In addition, research pertaining to disorders of behavior and cognition associated with specific forms of learning disabilities, attention deficits, and hyperactivity is being supported. A portion of these efforts focuses on studies of the neural circuitry that underlies perception and cognition, as the groundwork for understanding learning disabilities.

The NICHD thus has a broadly defined program that addresses learning disabilities in the context of a developmental framework. The general approach involves studies designed to elucidate biological and behavioral mechanisms that underpin normative capacity to learn and to develop cognitive competence. Data derived from such research provides investigators with the necessary baselines to detect and characterize impaired learning in children and to characterize the aspect(s) of learning and cognition that have been affected. In addition, the Institute sponsors a wide array of projects designed to characterize specific learning deficits associated with the inability to acquire the capacity to read. The program of research employs both animal models and studies of children that span the ontogenetic trajectory from the fetal period of development through infancy, childhood, and adolescence, until the beginning of adulthood.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

Over the years, the major contribution made by the Institute has been through the support provided to researchers who have studied the cognitive and perceptual capacity of normal human infants. In general, this research has revealed that human babies are not the passive unaware beings they were thought to be as recently as twenty years ago. Rather, they are now known to be capable of not only sensing the world around them but also processing such information and being "cognitively aware." This basic information has provided the methodological rigor for researchers to ask questions of human infants about their information processing capacity (and conversely about impairments of such capacity). NICHD-sponsored researchers have pioneered studies that have discovered when human babies can first distinguish aspects of language. This information could be valuable in screening infants early in life for potential language disorders.

The earliest period of development now being studied is incorporated in research designed to discover when and what fetal animals can learn.

Institute-sponsored researchers have, for example, discovered that rat fetuses can learn associations and instrumental responses as early as the 17th day of gestation (equivalent to the third trimester in human fetuses). These conditioned responses are retained by the rat pups up to 16 days after birth. This information could be utilized in prenatal behavioral toxicology studies.

Animal models developed by NICHD researchers have been used to study learning mechanisms that are necessary for adaptation and behavioral development early in life. Studies supported by the Institute have elucidated how naturally occurring species-specific behavior during the first days of life of rat pups depends upon reward in the context of mother-infant interaction. Further, they have demonstrated, using autoradiography techniques, which brain loci are associated with such learning. This type of learning is also a necessary mechanism for establishing attachment.

Major new initiatives have been undertaken in the quest to understand specific learning disabilities. The Institute is supporting research employing an animal model, which is focusing upon neurological and immunological mechanisms that may be involved in learning disability. In addition, the Institute is sponsoring an investigation of human brain tissue of people who were diagnosed prior to their death as being dyslexic. Such work is focusing on what anomalies were present in the neural tissue of these brains, with a view toward discovering common factors that may account for the observed, documented learning deficits.

At present, most of the reported findings in the literature on dyslexia are based on studies of dyslexics without knowledge about the etiology of their disability. Another focus of the Institute therefore is to develop ways to classify, if possible, different types of dyslexic individuals. If discrete groups of dyslexic individuals can be identified, more detailed studies can be mounted to determine mechanisms that are uniquely causal of the observed learning disabilities. In this regard, a dramatic finding by Institute-sponsored researchers has recently been reported. Investigators have identified chromosome 15 as being linked to an intergenerational form of dyslexia. Work is now under way to replicate the initial linkage findings and to identify where on chromosome 15 the marker for this type of dyslexia exists. Such research is the first to discover a biological marker and can be of significant help in leading to the discovery of the etiology of this specific form of dyslexia.

NICHD researchers have also been studying the evolution of language. Their research has focused upon the capacity of pygmy chimpanzees to learn symbols and comprehend spoken English. Researchers to date have found that this primate species can learn aspects of language and does have the capacity for understanding English words. Researchers during the course of their studies have learned how to teach language to this primate and, in so doing, learned some basic principles for teaching language-impaired children a form of reading. The investigators have adapted the symbols taught to the chimpanzees for use with severely retarded children. They are now employing the symbol-learning procedure to teach these children how to decode the symbols and thereby learn to communicate with their parents and teachers.

OPPORTUNITIES AND NEEDS

The future of research on learning disabilities is a promising one, particularly for the specific learning disabilities associated with the inability to read. The discovery of the association of a chromosome 15 anomaly with dyslexia holds out the likelihood that this marker can aid researchers in elucidating the mechanism(s) responsible. Further, this discovery may herald the possibility that other biological markers will be found. Should they be identified, researchers will be in a position to create a meaningful subtypology for this learning disability. This state of affairs would eventuate in an enhanced ability to create homogeneous groups of research subjects who could be rigorously compared and contrasted for elucidating mechanisms involved in dyslexia. Positive results of this effort should lead to more effective intervention and remediation procedures.

Interdisciplinary research in the field of developmental behavioral biology is now in a unique position to address the biological and behavioral underpinnings of learning disabilities. With new approaches employing brain-behavior, behavior genetics, and behavioral endocrinology foci, investigators can ask questions about learning that were not possible even a decade ago. The future of this field holds great promise for elucidating basic learning mechanisms essential for normal development. Such findings are essential for defining the nature of specific learning disabilities and how to intervene effectively in early development to ameliorate the deficits associated with such disabilities.

EXPENDITURES

Funding provided by the NICHD for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	4,307,022	(66)	5,138,952	(73)	5,900,000	(78)
LD-Related	31,483,122	(361)	33,192,677	(372)	38,100,000	(397)
LD Total	35,790,144	(427)	38,331,629	(445)	44,000,000	(475)

E. NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

The National Institute of Environmental Health Sciences (NIEHS) conducts fundamental biological research on the health effects of man's environment. Its research programs represent a response to current and emerging environmental problems. The goal of the NIEHS is to provide the scientific information base, advanced scientific methodology, and trained scientific personnel to reach an understanding of the total impact of environmental factors on human health. The Institute pursues its mission by supporting basic and applied research on the consequences of the exposure of human and other biological systems to potentially toxic or harmful agents in the environment. Through its research programs, the Institute seeks to provide an essential knowledge base about the impact of environmental factors on human health. This information is used by agencies charged with devising and instituting control or therapeutic measures for environmental factors.

A causal relationship between a specific learning disability and an environmental factor has not been established. However, a number of environmental factors such as heavy metals and pesticides have been shown to affect behavioral and neurological systems. These types of effects, particularly during early development, could contribute to the development of behavioral problems and learning disabilities.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The NIEHS has no research activities focused specifically on learning disabilities. However, there is an active program to identify neurotoxic and behavioral effects of environmental factors, and to determine their mechanism(s) of action.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

- An animal model of cognitive dysfunction and structural indicators of neurodegenerative disease is being developed in rats. This model will be useful in the development of strategies for the treatment or prevention of neurodegenerative disease involving cognitive dysfunction. Studies to date have emphasized the direct administration of cytotoxicants such as AF65 and colchicine directly into the brain areas that are known to mediate learning and memory in rats. Data indicate that direct administration of colchicine into the area of the nucleus basalis produces a behavioral model of cognitive dysfunction in rats.

- A study is under way to evaluate the impact of exposure to polychlorinated biphenyls, polybrominated biphenyls, and eight chlorinated hydrocarbon pesticides on cognitive and behavioral functioning in early childhood.

- Although the nervous system has been identified as the target for alkyl-mercurials and -leads, much less information is available concerning the health hazards from environmental exposure to alkyltins. Memory impairment is one of the prominent clinical signs of alkyltin poisoning. A nonhuman primate model is being developed to assess the neurobehavioral effects of alkyltins. The objectives of this study are to determine the effects of these agents on short-term memory and to correlate neurobehavioral changes with histopathologic damage in the brain.

- Clinical studies have shown a correlation between chronic low level lead in the blood of humans--especially children--and various behavioral deficits, including emotional problems, hyperactivity, reduced reaction time, lowered IQ scores, and learning difficulties in school. The cellular neuronal dysfunctions caused by chronic lead exposure are still not well understood. A model using the gastropod Lymnaea stagnalis for identifying the mechanisms whereby lead exposure affects neuronal functioning is being developed. In another study, the efficacy of various treatment outcomes for moderately lead-toxic children is being explored. As a part of this study, a device is being tested that may provide a noninvasive method for routine screening of lead concentrations in children.

- Data on the effects of lead exposure on behavior from birth through 12 months of age have been obtained as well as information on the interaction between parental caregiving and degree of infant lead exposure. The level of physical and social stimulation available to the infant and the degree of maternal involvement were negatively correlated with lead exposure. This correlation was significant only after the infant was 6 months of age. Lead exposure during the first year of life did not appear to substantially affect sensorimotor development. In addition, there is evidence that early development precocity leads to higher lead exposures. However, it is unwarranted to conclude that low to moderate lead exposure during the prenatal and early postnatal periods presents no risk to neurobehavioral development. Studies to obtain data on more sensitive measures of neurotoxicity are now being planned.

EXPENDITURES

Funding provided by the NIEHS for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	--		--		--	
LD-Related	5,376,890	(39)	7,525,688	(47)	7,826,715	(47)
LD Total	5,376,890	(39)	7,525,688	(47)	7,826,715	(47)

F. NATIONAL INSTITUTE OF NEUROLOGICAL AND COMMUNICATIVE DISORDERS AND STROKE

The National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) conducts, fosters, coordinates, and guides research on the causes, prevention, diagnosis, and treatment of neurological and communicative disorders and stroke, and conducts basic research in related scientific disciplines.

The neurobiological basis of learning disabilities is an important component of NINCDS research. A major responsibility of the NINCDS is the study of brain development and dysfunction as manifested in specific learning disabilities. Progress in understanding neural functioning in the basic learning processes is highly related to progress in identifying and understanding neural dysfunction in disorders of learning.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The spectrum of research activities specific to and related to learning disabilities supported by the NINCDS ranges from basic studies of the neurochemistry of cell memory to clinical studies of children with specific symptoms associated with learning disabilities. To stimulate research, a number of actions have been taken by the NINCDS, which are described below.

- In Fiscal Year 1982, the NINCDS issued a program announcement to encourage research grant applications on brain dysfunction in disorders of learning. The announcement encourages applications for the support of basic and clinical research on the neurophysiological and neurochemical mechanisms associated with specific and precisely defined learning disorders in children with normal intelligence, normal psychiatric status, and adequate environmental support. The purpose of this research is to develop knowledge of the neurophysiology of learning disorders and expand the capability of accurate diagnosis. Multidisciplinary approaches are encouraged.

- Two years later, the Institute issued a program announcement to encourage research grant applications on the neurophysiology of cognitive processes. The announcement is intended to stimulate new approaches to the experimental and conceptual aspects of research on the types of cognitive processes that can be studied at the neural level in both animals and humans. A primary goal is to characterize the sources and time course of neural activity related to these processes.

- Also in Fiscal Year 1984, a request for applications was issued to establish a multidisciplinary research center for the purpose of investigating brain development and function in disorders of language, behavior, and learning in infancy and early childhood. The goal was to conduct multidisciplinary investigations of both a clinical and basic nature for determining abnormal patterns of brain development and function in language, behavior, and learning disorders. In September 1985, a center was established at the University of California, San Diego.

- The Institute issued a program announcement in Fiscal Year 1986 on genetic aspects of speech, language, and reading disorders. Its purpose is to encourage applicants to investigate the possible contributions of genetic factors to the disorders of stuttering, speech articulation disorders, dyslexia, and children's developmental language disorders.

- In Fiscal Year 1985, the NINCDS published the report "Low Achieving Children" on 50,000 children followed to 7 years of age in the Collaborative Perinatal Project. According to the report, a broad array of biomedical, social, and behavioral characteristics had only "moderate explanatory power," and "exogenous or environmental factors" were more highly related to low achievement than endogenous ones.

- Difficulties in social competence are now being recognized as a significant component of learning disorders. In Fiscal Year 1986, the NINCDS convened a workshop on Development of and Neurological Basis for Social Cognition. Leading investigators conducting research on social interaction discussed measures of assessment and future research perspectives and initiatives.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

Learning Disabilities in Children

Neurophysiological research into brain function has shown that electrical activity at the scalp recorded during active selection and interpretation of stimulus information is uniquely associated with either reading disorders or attention deficit disorders in children 8 to 12 years of age. Among the children with reading disorders, these event-related potentials (ERP) also differentiated between subtypes of reading disability. Results provide objective electrophysiological methods for discriminating between normal and learning-disabled children. Currently, the electrophysiological and behavioral measures used with the older children are being applied to younger prereading children at genetic risk for developing reading disorders, to cross-validate the techniques and assess their value as predictors of problems in reading and attention.

In a related area, a comprehensive evaluation is being made of the clinical usefulness of Neurometrics, a commercially available program of quantitative electrophysiological techniques to identify abnormal brain functions primarily in school-age children with learning problems. In two populations of learning-disabled and normal children, the sensitivity and specificity of the Neurometrics test is being compared with more conventional clinical techniques and with other electrophysiological recordings that are made during active signal detection (ERPs) rather than during rest.

A comprehensive research program investigating the neurological basis of language, learning, and behavior during infancy and childhood includes techniques of brain imaging, electrophysiological recordings (ERP), indices of metabolic function, and behavioral measures. In addition to samples of language-impaired children and normal controls, children with localized lesions, Williams syndrome (a genetic disorder accompanied by low cognitive functioning), and those exposed to alcohol in utero are being studied. The strength of this research lies in its multidisciplinary approach to the development of language and cognitive disorders. Significant information is being obtained from the event-related potential recordings. Differences in waveform and symmetry have been found between infants and adults in response to words; and in children with Williams syndrome, a striking asynchrony in ERPs recorded over the left and right hemispheres of the brain suggests abnormal hemispheric integration.

A related program of research is developing an empirically derived classification system for disorders of higher cerebral function in children, which includes developmental language disorders (DLD) in the preschool period. An assessment battery has been designed for children with developmental language disorders that will differentiate this group from children with autism or mental retardation. Preschool children identified in this study as having DLD were reported to have bilateral motor abnormalities at later ages. These findings support an hypothesized bilateral brain dysfunction in this group.

A study of auditory discrimination in children with speech, language, and learning disabilities is establishing prevalence estimates of difficulties in their auditory discrimination and is evaluating the effects of training in auditory perception on the handicapping conditions. The goal is to improve diagnostic and rehabilitation procedures for children seen in speech, language, and hearing and learning-disability clinics. In a separate study, the effects of middle ear disease (otitis media) on the acquisition of language and reading skills is being investigated in two groups of children followed longitudinally from birth and from age 3. Otitis media and the conductive hearing loss that may result has been recognized as a possible etiological factor in learning disabilities.

Attention deficit disorder is sometimes found to accompany learning disabilities in childhood. While stimulant medication may improve performance on laboratory tasks assessing attention, it has not been found to improve academic performance among children with attention problems and/or hyperactivity. One study is investigating the effects of the stimulant drug methylphenidate (Ritalin) on a range of cognitive behaviors in children with attention deficit disorder and hyperactivity, including divergent thinking, which may be negatively affected by stimulant drugs. On a more basic level, other research is investigating the relationships between neurochemical indices in specific catecholaminergic systems and attention deficit disorder. Results should provide a basis for more effective therapy.

Developmental agraphia is being studied in children by identifying the linguistic and motor components necessary for correct spelling and letter formation. The model used was derived from studying adult patients with acquired agraphia. Disruption of specific components is hypothesized to produce specific agraphias. The type of agraphia present in a given child will be compared with the type of dyslexia that may be present. Better understanding of these disorders will lead to the development of more effective remediation techniques.

A computerized diagnostic test for dyslexia is being developed for children in grades 2 through 6. The focus is on the component skills of reading. Differences in skill profiles between dyslexics and normal readers and differences within dyslexics are being identified. Once the item pools are refined through cluster analysis, the test will be implemented on microcomputers.

Basic Processes of Learning

The two major categories of research on learning processes in humans are investigations of the effects of various brain lesions and studies of mechanisms underlying the perception and processing of speech and other linguistic information, including sign language.

In the first category, the patient populations studied, often together with groups of normals, include commissurotomy or split brain patients, those with damage to the prefrontal cortex, frontal or temporal lobes, Broca's aphasics, and aphasic patients who have had strokes. The specific perceptual and cognitive deficits identified are correlated with the known site and severity of damage to the brain, often determined by brain imaging techniques (CT scan, MRI, PET) and electrophysiological recordings (EEG, ERP). In patients with seizures, recordings are made during task performance from implanted electrodes as well as from those on the scalp. A wide range of cognitive tasks are being studied including language deficits and academic skills in children with right or left hemisphere lesions, selective attention and distractibility, deficient memory for verbal and nonverbal material, and inadequate motor control. Studies of aphasia are focused on specific aspects of receptive and expressive language functions and on the changes associated with recovery.

In the second category, effects of various degrees of hearing loss are being investigated, as are electrophysiological indices of cortical and brainstem processing of speech and other sounds, individual characteristics related to language lateralization such as androgen levels, handedness, and sex of subject, and the course of acquisition of sign language and of literacy in the deaf.

Animal research supported by the NINCDS includes studies of cellular mechanisms underlying associative learning in the sea slug, crayfish, and goldfish, the imitative learning of song patterns in the canary and zebra finch, and the neural control of memory and motor behavior in the monkey. The role of the hormone vasopressin as a possible facilitator of learning and memory is being studied in rats. In other research, the recognition site in the brain for the stimulant methylphenidate is being characterized and its relationship to the dopamine transport complex is being studied in an animal model of hyperactivity. Because learning is one of the fundamental capabilities of most if not all nervous systems, animal studies will contribute to knowledge of the general mechanisms involved both in the normal function and in some dysfunctions of the human brain.

OPPORTUNITIES AND NEEDS

The rapidly expanding knowledge base in the neurosciences is presenting new and exciting opportunities for productive investigation into the complex research puzzles presented by learning disabilities. To facilitate this research, a major goal is the identification of specific learning disabilities through precise diagnostic criteria that are reliable and reproducible. Another major goal is further encouragement of investigators with neuroscience skills to address the fundamental processes of learning and of learning disabilities. Genetic studies of familial patterns of learning disabilities represent a particularly promising investigative approach. When the fundamental processes of learning are more fully understood, more successful strategies for treatment and prevention will be possible.

EXPENDITURES

Funding provided by the NINCDS for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	3,180,000	(10)	3,149,000	(11)	3,563,000	(13)
LD-Related	8,514,000	(63)	8,107,000	(59)	9,169,000	(63)
LD Total	11,694,000	(73)	11,256,000	(70)	12,732,000	(76)

G. NATIONAL INSTITUTE OF MENTAL HEALTH

The mission of the National Institute of Mental Health (NIMH) is to improve the understanding, treatment, and rehabilitation of the mentally ill, to prevent mental illness, and to foster the mental health of the American people. These goals are accomplished by supporting research, generating and transmitting new knowledge, demonstrating new technologies, and guiding National policy.

Learning disabilities research is an important focus of the National Institute of Mental Health. Studies of how people learn, how learning processes go awry, and how principles of learning help to overcome pathology have been gradually transforming the field of learning and mental health over the past decade. These developments in basic research include a greater integration of significant ideas and methods as well as more complex and conceptually varied investigations of normal learning processes. These studies have direct relevance and application to learning disabilities and disorders.

ACTIVITIES RELATED TO LEARNING DISABILITIES

Research on normal learning processes has begun to show that many factors (including individual, family, and environmental) interact with and influence learning and performance. For example, studies of motivational and reinforcement processes, choice, emotions, perception, attention, memory, and social contexts have begun to clarify the underlying mechanisms that enhance, inhibit, or distort learning. Moreover, a number of models that incorporate these investigations of processes have significantly expanded the understanding of how people learn.

The NIMH supports research and clinical research training in the psychopathology, etiology, diagnosis, classification, longitudinal course, treatment, and rehabilitation of the mental disorders and clinical problems of children and adolescents, including specific developmental disorders involving impairment in reading, arithmetic, and language as well as attention deficit disorder/hyperactivity (ADD/H).

The current program in specific learning disorders is small. One project involves a study of cognitive phenotype in familial dyslexia, and another is concerned with a comparative evaluation of sensory integration therapy.

Research generally related to learning disorders is more extensive. With regard to ADD/H, for example, recent evidence suggests that it is not outgrown at puberty but that some of the symptoms may persist into adolescence and adult life. Many affected individuals have ongoing difficulties in school performance and some exhibit antisocial behavior. Ongoing research is focused on answering a number of questions about this disorder.

Research in the neurosciences contributes to knowledge of brain mechanisms underlying both normal behavior and psychopathology. A number of research areas relating to higher cognitive function have long-term potential implications for understanding the deficits incurred in learning disabilities, including learning, memory, central nervous system development, neuronal plasticity, hormonal influences, neuronal substrates of attention and perception, cortical organization and function, and neurobehavioral toxicology.

The NIMH also conducts clinical research on psychiatric disorders of childhood and particularly on psychobiological aspects of these disorders. The developmental disorders have as core deficits delayed and/or deviant development of basic functions such as speech, language, attention, social skills, perception, and motor skills. Traditionally, these skills and their disruption have been the interest of clinical neurology, which has sought to focus studies of cerebral dysfunction in adults with acute central nervous system insults. New brain imagining techniques promise both more resolute visualization of anatomy and opportunities to study localized function of the central nervous system in patients without macroscopic lesions visible on neuroanatomical scans. Specific developmental disorders seem intuitively to be among the most appropriate clinical entities to examine with these techniques. In addition, the overlap between learning disabilities and ADD, seen clinically, raises issues concerning possible common biological underpinnings and subtyping based on biological findings that might be addressed with these techniques. Such techniques have recently been applied to the study of developmental dyslexia and ADD as well as to infantile autism.

Two other techniques appear to be especially useful for studying attentional dysfunctions that may be involved in developmental disorders: event-related potentials and eye movement recordings (infrared oculography). These techniques are being applied to the study of developmental dyslexia.

HIGHLIGHTS AND PROGRAM ACCOMPLISHMENTS

Dyslexia

A substantial portion of the research on learning disabilities has focused on one specific problem, that of dyslexia, or reading disability. There is a growing trend to view dyslexia as heterogeneous. The two typologies most relevant to mental health focus on two areas: visual information processing, and verbal processing of language. There have been two substantial breakthroughs in these areas. The first has been the demonstration of the eye-fixation methodology as an invaluable approach in tracing underlying linguistic and perceptual processes in skilled reading at detailed levels. This approach provides a direct measure of ongoing cognitive processes in reading, some of which may leave no conscious memory trace in the individual. With this method, investigators can track sequences of cognitive processes relevant to complex tasks such as language comprehension, visual puzzles, visual analogies, and mathematical problems. The second breakthrough, also using eye-fixation methodology, has been the finding that gazing, or the uninterrupted looking at a single stimulus unit (rather than an individual eye-fixation) was most closely related to cognitive processing in reading. Thus, investigators have been able to show that dyslexics have two major deficits: (1) slow verbal retrieval and (2) difficulty in developing syllables (or the "chunks") that underlie fluent word identification. Another important finding is in the realm of visual information processing or problem solving. Studies have shown that dyslexics lack the visual representations that are critical to fluent reading. This research has also demonstrated that individual differences such as spatial ability play an important role in how cognitive processes influence comprehension of an object, particularly three-dimensional objects.

This important knowledge base is now making it possible to expand research on reading disabilities to understand better how cognitive skills in reading are acquired and how cognitive reading dysfunctions develop. Investigators are beginning to investigate the nature of decoding skill (word recognition) by dyslexics in both children and adults. The research will examine the nature and source of dyslexics' word recognition problems, including slow verbal retrieval. The central aim of these studies is to determine the cognitive profiles of dyslexia and to determine if they correlate with other aspects of the specific reading disability. Potentially, such studies will begin to shed light on the heterogeneity issue--that is, whether deficits in language processing and deficits in visual problem solving reflect distinct disabilities or are qualitative variations of a single type of dyslexia over time; and whether the two typologies are manifestations of the same syndrome at different developmental ages.

Extensive study of right-handed men with severe developmental dyslexia and their matched controls has been completed, and data are being analyzed. This sample has been studied with a xenon inhalation technique for measuring regional cerebral blood flow (RCBF), electroencephalographic (EEG) spectral analysis, event-related potentials (ERPs), magnetic resonance imaging (MRI), neurological examinations for subtle signs, and neuropsychological testing. Results of a pilot study of a portion of this sample with MRI suggest subtle abnormalities of temporal symmetry. This finding is compatible with neuropathological work on dyslexia. RCBF studies using neuropsychological activation tasks show group differences in hemispheric symmetry as well as in antero-posterior gradients.

Attentional dysfunction in dyslexia has been studied with an extensive ERP battery designed to differentially evaluate the ability to initiate, select, inhibit, shift, and sustain attention in both visual and auditory modalities. A severely dyslexic sample has been characterized as dyslexic with or without a history of ADD. Preliminary results suggest that attentional dysfunction may constitute an important subgrouping dimension. Neuropsychological studies suggest that severe developmental dyslexics show continuing deficits in verbal learning, visual-auditory associative learning, phonetic decoding and encoding, and language processing. In general, the subgroup with positive ADD ratings appears to perform worse than those negative for ADD on such measures.

Attention Deficit Disorder/Hyperactivity

A distressing finding in recent years is the increasing awareness of the limitations of psychopharmacological treatment in ADD/H. It is apparent that psychostimulant medication enhances attention and reduces disruptive behavior for prepubertal ADD/H children. It was hoped that 2 to 3 years of early treatment would provide sufficient performance increments and enhancement of self-esteem to carry the child over the pubertal transition. Data from a number of longitudinal studies, however, have shown that this is often not the case. Subsequent to discontinuation of drug therapy at approximately age 13, levels of social functioning and interpersonal skills continue to be lower for ADD/H adolescents and young adults than for their age-matched normal peers. This finding is especially true for that subgroup who displayed assaultive or aggressive behavior in childhood. Adolescents and young adults may carry over one, two, or three of the symptoms of ADD/H, and those who carry over multiple symptoms seem to be at higher risk for substance abuse.

A new study of stimulant drug therapy with ADD/H adolescents is currently under way. Preliminary results indicate that, as a group, these ADD/H adolescents show a good clinical response to methylphenidate therapy and exhibit enhancement of cognitive processes as reflected in performance and event-related potentials collected in memory scanning and vigilance tests. These findings are consonant with the previous work with adults and will contribute to the knowledge of effective treatment for ADD/H-residual type over the life span.

At the 1986 meeting of the American Psychological Association, a preliminary finding of great potential was reported. In a study of ADD/H boys looking at the effects of diet and sugar intake on the symptoms of ADD/H, normal boys, given a sugar challenge, suppress cortisol while boys with ADD/H do not. If this finding is replicated, a biological marker for ADD/H will have been found. Such a biological marker could aid in diagnosing and subtyping this group of disorders and may have relevance to different therapeutic approaches and interventions. It should be emphasized that this is a preliminary finding.

In an attempt to localize abnormal patterns of glucose utilization in ADD, adults with attention deficit disorder, residual type (ADD-RT), are being studied with positron emission tomography (PET) and fluorodeoxyglucose while performing an auditory attentional task. Preliminary data suggest lower whole brain rates of glucose utilization in patients. In addition, trends toward regional differences are seen. Final data analysis is in progress.

Basic Neurosciences

Research on the neural basis of higher order integrative activities--attention, perception, and cognition--currently focuses on the basic mechanisms for the coding and representation of information in the nervous system. New methods have made it possible to determine the "birthdays" of neurons that form specific structures and to follow their migration from germinal zones in the neural plate state through the differentiation of specific cell classes and to the formation of functional synaptic connections in particular structures. Developmental neurobiology has elucidated the maturation processes of the cerebellum, spinal cord, and portions of the visual system in embryos and fetuses. This work lays the foundation for understanding the ontogeny of those portions of the nervous system critical for perceptual and cognitive processes as well as sensorimotor behavior.

Progress in the area of information processing has been extraordinary. For example, detailed information-processing models have been developed in the functional areas of reading and listening. These models describe several levels of internal coding and their interconnections. The models provide an impressive approach to the way in which the brain functions during realistic cognitive activities that can be accessed from visual or auditory input channels.

Studies of the neural basis of learning and memory show that neurons are capable of being modified by experience. Current work seeks strategies through which to relate these findings in isolated neuronal systems to learning. The model system approach to the cellular basis of learning, used with simplified invertebrate systems, has generated important findings. The progress realized with invertebrate preparations is validating the model system approach itself and is strengthening the assumption that learning can be studied at a cellular/molecular level. Moreover, the invertebrate systems that have been used are proving to have a broader behavioral repertoire than initially envisioned, and they promise to be productive for the study of associative as well as nonassociative forms of learning. The few systems currently being considered indicate the feasibility of such analyses; nevertheless, it is essential that vertebrate model systems be developed. It appears that the powerful analytic techniques applied to the invertebrate systems (the study of ion channels with voltage and patch clamp techniques) may be applicable to vertebrate systems as well. The development of vertebrate models is being facilitated by the remarkable advances in methods for studying the connectivity of the vertebrate nervous system in vitro.

OPPORTUNITIES AND NEEDS

In the area of behavioral science, research is needed that will more clearly differentiate the various types of reading disabilities; clarify the relationship between emotional and behavioral problems and learning disability; examine how learning disabilities affect an individual's general sense of competence; and assess the impact of the attitudes and behaviors of other people on the learning disabled individual.

In the area of child and adolescent disorders, there is a need to increase research on the diagnostic assessment, etiology, associated features, and treatment of various developmental disorders of reading, arithmetic, language, and articulation that affect preschool and school-age children. For both learning disabilities and attention deficit disorder, studies are needed in the development, refinement, and evaluation of instrumentation and methodology of assessing, classifying, and diagnosing the disorder. Studies of the course of the disorder, symptom change, response to treatment, and social functioning are also needed.

With the increasing availability of technologies based on genetic strategies, work in neuroscience areas relevant to learning will require a new emphasis in molecular neurogenetics. Elucidation of the genetic processes responsible for the development of a mature, normally functioning brain will significantly advance the ability to understand the disordered processes of brain function.

Research also is needed to delineate brain regions (cortical and subcortical) which may be involved in dyslexia and ADD and their combination. Additional study both with physiological imaging techniques (PET and RCBF) as well as with other physiological techniques (ERPs and eye movement recordings) may help provide a useful nosology with implications for treatment.

If preliminary research findings from event-related potential studies hold up, it will be desirable to extend such research by studying subgroups of boys with dyslexia with and without ADD and with pure ADD.

EXPENDITURES

Funding provided by the NIMH for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (est.)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	1,895,360	(17)	1,947,834	(16)	2,276,058	(13)
LD-Related	8,349,825	(70)	8,995,055	(74)	9,703,195	(67)
LD Total	10,245,185	(87)	10,942,889	(90)	11,979,253	(80)

H. CENTERS FOR DISEASE CONTROL

The mission of the Centers for Disease Control (CDC) is to lead public health efforts to prevent disease, disability, and premature death and to improve the quality of life. The CDC pursues this goal through prevention and control of infectious diseases; prevention of disease, disability, and death associated with environmental and workplace hazards; prevention and control of chronic diseases; and the promotion of health. In addition, the CDC provides support to local, State, academic, national, and international community prevention efforts in the basic disciplines of epidemiology, surveillance, laboratory sciences, and training. Specific Centers and Institutes have been established to work on infectious, occupational, and environmental causes of disease. Others promote health education and preventive services. The CDC has recently focused increased emphasis on chronic diseases. Since developmental disabilities/mental retardation are common chronic conditions, the CDC has an interest in this area.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The CDC activities relate to learning disabilities in general rather than specifically. The CDC conducts epidemiologic research that could lead to improved understanding of the possible interrelated roles of heredity and environmental exposures as causes of learning disabilities. Current research focuses primarily on environmental causes of birth defects and mental retardation. Findings in these areas could have important implications for the entire learning disabilities field.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

The CDC, through a cooperative agreement funded by the Agency for Toxic Substances and Disease Registry (ATSDR), is collaborating with the State of Georgia to identify cases of mental retardation in the metropolitan Atlanta area and to conduct case-control studies to test hypotheses that various environmental exposures have caused the problem. A second focus of the CDC-Georgia project is the study of environmental causes of very low birth weight. Since very low birth weight babies are at high risk of developing learning disabilities, identification of environmental causes of very low birth weight could lead to important interventions.

OPPORTUNITIES AND NEEDS

School systems are major collaborators with the CDC in the surveillance of mental retardation. The willingness of the public schools to share their extensive records, while protecting confidentiality, has proven to be an important aspect of case identification. As the surveillance methodology is refined for mental retardation, it could then be applied to the learning disabilities area. Similarly, if environmental causes of mental retardation are discovered, testing of possible associations with learning disability should be done.

EXPENDITURES

Funding provided by the CDC for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (est.)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	--		--		--	
LD-Related	241,600	(1)	357,230	(1)	600,600	(1)
LD-Total	241,600	(1)	357,230	(1)	600,600	(1)

I. FOOD AND DRUG ADMINISTRATION

The Food and Drug Administration (FDA) is a scientific regulatory agency responsible for the safety of the nation's foods, cosmetics, drugs, biologics, medical devices, and radiological products. Specifically, the agency's mission is to assure that food is safe and wholesome; drugs, biological products, therapeutic devices, and diagnostic products are safe and effective; cosmetics are safe; the use of radiological products does not result in unnecessary exposure to radiation; and all of these products are honestly advertised and labeled.

Manufacturers have the prime responsibility for assuring the safety of their products. The FDA's role is to monitor industry and to provide the consumer with the best assurances possible that industry is meeting its responsibility. Central to the agency's strategy is the availability and analysis of credible scientific data. The determination of product safety, prior to approval for use by the general public, is based in part on extensive testing and evaluation for any risk of toxic effects on the human population. Recognizing the fact that the definition of safety is continually changing and becoming more subtle and sophisticated with the growth of the science of toxicology, the FDA continually strives to improve the scientific input into its decision-making process by expanding its use of advisory committees to obtain the advice and recommendations of the best scientific talent in the country, judiciously allocating resources for contract research, and placing emphasis on improving in-house scientific capabilities. Among its activities, the FDA conducts research to identify, reduce, and control consumer risks and to develop improved methodologies and protocols for evaluating the safety of chemicals and other products.

ACTIVITIES RELATED TO LEARNING DISABILITIES

Potential neurotoxicity is an important facet of safety evaluation processes. Traditionally, the major accepted indices of neurotoxicity have included neuropathology and overt manifestations of neurological dysfunction. Because of considerable progress being made in the neurosciences, it is now recognized that diverse chemicals, and even some nutrients, may influence the neuronal control of behavioral and neurophysiological processes such as learning, attention, sleep, and mood. Toxicologists have begun to expand the conceptual definition of neurotoxicity to include neurochemical, neurophysiological, and particularly, behavioral changes as additional indices of potential toxic effects on the nervous system. In an effort to stay abreast of this rapidly developing facet of safety evaluation, a part of the overall research objectives within the FDA is devoted to supporting studies dealing with the detection and assessment of the biological significance of various neurochemical, neurophysiological, and behavioral endpoints as indices of neurotoxicity. The scope of work sponsored by the FDA in this area includes efforts to investigate the effects of dietary and other chemicals on brain function, to define how factors such as diet, stress, or age might influence the development and expression of neurobehavioral toxicity, and to validate experimental models of neurobehavioral toxicity, appropriate for the functions of the regulatory decision process. Within the context of the agency's interest in neurobehavioral toxicity, learning disability and the factors contributing to cognitive dysfunction in the developing and mature organism are included as critical manifestations of the adverse effects of chemicals on the central nervous system.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

The FDA's activities related to learning disabilities involve the contributions to the scientific data base for defining reliable and sensitive models of neurobehavioral toxicity. Studies have demonstrated the fact that credible neurobehavioral testing can be performed if proper attention is paid to study design and appropriate test methodology is employed. An important facet of the agency's work focuses on factors related to the assessment of risk. With a view toward determining which factors are most appropriate for defining the characteristics of a population at risk, efforts have been initiated to identify those variables which affect the level of susceptibility to potential neurobehavioral toxicants. Variables such as genetic background, gender, age, diet, and perinatal factors have all been shown to be particularly important in the development and/or expression of neurobehavioral toxicity.

- The impact of varying dietary constituents on brain function is being investigated. For example, studies are under way to investigate the behavioral and pathological effects of diet-induced zinc deficiency in weanling rats.
- Studies are being conducted to determine the utility of nonrodent model systems for characterizing chemically-induced neurobehavioral dysfunctions.
- The sensitivity and utility of defined test procedures used to assess the cognitive development of the preweanling rat are being evaluated.

- A rodent model is being developed to determine the neurofunctional consequences of perinatal exposure to factors associated with caesarean birth, such as anesthesia and surgical stress.

- The neurotoxicological potential of subacute dietary exposure to triphenyl phosphate is being assessed.

- Neurobehavioral changes are being characterized in the intact organism associated with exposure to compound A23187, a chemical ionophore known to facilitate calcium transport across biological membranes.

- A determination of whether chronic exposure to marijuana smoke results in behavioral impairments or neuropathological alterations in the young male rhesus monkey is under way.

- Begun in 1978, an interlaboratory study was designed to focus primarily on the evaluation of the reliability of behavioral testing methods, the sensitivity of these methods to alterations produced by prenatal chemical exposure, and the effects of experimental variables such as litter size, sex of the animals, and prior testing experience on the behavioral responses.

- An evaluation is being conducted of current scientific opinion as to the use of conventional toxicologic testing for predicting neurotoxicity and behavioral dysfunction, along with identification of needs for improving the reliability and comprehensiveness of the prediction of such effects in humans.

- A comprehensive evaluation of the morphological and behavioral teratogenicity of two dental anesthetics is under way. This research is being undertaken because preliminary clinical studies have suggested that prenatal exposure to dental anesthetics via exposure of patients or health care workers may produce spontaneous abortion, fetal malformations, and/or subtle learning disabilities in offspring.

- A study has been initiated of dietary amino acids and brain function. Its objectives are to develop an experimental animal (rodent) model that will enable the detection and interpretation of biologically significant changes in brain function, particularly as they relate to the potential nutrition-brain interrelationships and possible biochemical mechanism involved; to determine the extent to which the ingestion of food-related compounds, which might result in changes of amino acid balance, may affect the functional state of synaptic/receptor activity of select neurotransmitters; and to determine whether the characteristics of any treatment-related neurochemical changes vary with the experimental conditions such as route of administration, dietary status, duration of exposure, or circadian cycle.

- The impact of varying dietary constituents on brain function is being investigated. Studies will focus on the neurofunctional consequences of altering the ratios of carbohydrate to protein in the diet.
- An examination is being conducted of the neurobehavioral immunologic responses to food-related toxicants to determine the extent to which those responses are interdependent and may be modified by defined nutritional variations or altered endocrine state.
- The effects of amino acid imbalances on CNS excitability and neurobehavioral function in the rodent are being studied.

OPPORTUNITIES AND NEEDS

While considerable strides have been made in establishing the need for and the utility of behavioral testing in safety assessment, there are a number of important issues that remain to be addressed in both the scientific as well as the regulatory communities. Among the scientific issues is a pressing need to understand better the relationship between particular behaviors and the underlying biological mechanism. This information will be essential to enable cross-species extrapolation and, in particular, to determine the clinical relevance of neurobehavioral results from animal studies to the human population. In addition to the basic science issues, there is a need to develop or refine regulatory concepts to deal with chemicals that may induce subtle changes in neurobehavioral function, possibly in only certain susceptible subpopulations. One of the more problematic questions that will necessitate a close interaction between the scientific and the regulatory communities is the appropriate criteria for defining a behavioral or functional change as adverse. Neurobehavioral evaluation will ultimately be included among the routine criteria for the safety assessment of regulated chemicals. The results will serve to lessen the exposure of humans to potentially neurotoxic chemicals that might predispose or otherwise contribute to conditions such as learning disability.

EXPENDITURES

Funding provided by the FDA for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (est.)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	--		--		--	
LD-Related	907,650	(11)	845,760	(9)	866,900	(8)
LD Total	907,650	(11)	845,760	(9)	866,900	(8)

J. HEALTH RESOURCES AND SERVICES ADMINISTRATION

The Health Resources and Services Administration (HRSA), among its many activities, provides leadership and support in integrating health services delivery programs with public and private health financing programs; supports States and communities in their efforts to plan, organize, and deliver health care to mothers and children; and administers health services block grants, categorical grants, and formula grant-supported programs, including some research activities.

The Bureau of Health Care Delivery and Assistance (BHCDA) of the HRSA helps assure that medical care services are provided to persons living in medically underserved areas and to persons with special health care needs. The BHCDA's Division of Maternal and Child Health (DMCH) is the unit within the HRSA that is responsible for research, training, and service demonstration activities related to the prevention and amelioration of learning disabilities. The DMCH administers programs authorized initially in Title V of the Social Security Act of 1935. Subsequent amendments provided funds for mentally retarded children, established training and research authority, and authorized the Programs of Projects (Maternity and Infant Care, Children and Youth, Dental Care, Intensive Infant Care, and Family Planning). In 1975, the Programs of Projects were merged into the formula grant to States, and in 1981, Public Law 97-35 created the Maternal and Child Health Services block grant and initiated a program of Special Projects of Regional and National Significance (SPRANS). The Maternal and Child Health Services block grant consolidated existing categorical programs into one block, which allows each State to develop its own programs and set its own priorities for services to children with learning disabilities.

Members of the DMCH interdisciplinary professional staff provide technical assistance and consultation to the States in developing coordinated, comprehensive systems of care for infants, children, adolescents, and young adults with learning disabilities. Consultation is available in the areas of audiology, early childhood education, nursing, nutrition, pediatrics, psychology, social work, and speech-language pathology.

For Fiscal Years 1982-1986, 85 percent of the block grant appropriation provided funds to States for health services for mothers and children to reduce infant mortality and the incidence of preventable diseases and handicapping conditions among children, including learning disabilities; rehabilitative services for blind and disabled individuals under the age of 15; and treatment and care for children with special health needs. For each fiscal year, 15 percent was set aside for Special Projects of Regional and National Significance, including genetics, hemophilia, research, training, and other special projects.

The set-aside was used to support overall State maternal and child health efforts in a variety of ways to prevent learning disabilities where possible and to improve the service delivery system for children with or at high risk for learning disabilities. The DMCH, for example, has established and continued interagency collaborative efforts with the Office of Special Education and Rehabilitative Services (OSERS) and the National Institute of Mental Health (NIMH) at the Federal level to stimulate family-centered, community-based, and State-coordinated systems of care for all children with special needs. Children with learning disabilities and their families have been included in this effort.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

At the present time, HRSA activities related to learning disabilities involve provision of services and research. The HRSA has a continuing commitment to developing a comprehensive and coordinated system of care for all disabled individuals, with community-level services that are responsive to the family, community, and culture in which the infant, child, or pregnant female lives. Building on collaborative efforts with the Special Education Program of the Office of Special Education and Rehabilitative Services, the DMCH participated in the development of regulations for the 1986 Amendments to the Education of the Handicapped Act (P.L. 99-457).

This collaborative activity between Federal agencies will help to make this legislation significant for persons with learning disabilities by focusing on the individual with the learning disability rather than on the learning disability as a category, diagnosis, or condition.

The DMCH is supporting major national efforts to improve the networking of services for children with special health needs, including those with learning disabilities. The current focus, again, is on the family, which both provides and receives health care.

State development grants are funded by the DMCH through the Special Projects of Regional and National Significance to allow States to support innovative programs and to develop resources. State grants focus on service delivery by expanding service quality or quantity, and coordinating services for children with special needs. Current programs in

Massachusetts, Minnesota, Texas, and Utah involve children with learning disabilities and their families.

OPPORTUNITIES AND NEEDS

The Division of Maternal and Child Health has a very strong commitment to removing gaps and improving services to children with disabilities and their families. Despite increased Federal, regional, State, and local efforts to deal with the gaps in services to children with learning disabilities, the gaps continue to concern all who are involved with these children. The overall goal is a comprehensive system of care for all disabled children, including those with learning disabilities. The DMCH will continue to work with many different groups and organizations to meet the needs of these children and their families.

EXPENDITURES

Funding provided by the HRSA related to learning disabilities includes services and research, as follows:

	FY 1985 (approx.)	FY 1986 (approx.)	FY 1987 (approx.)
	$	$	$
LD-Specific	17,500,000	18,700,000	19,900,000
LD-Related	8,500,000	8,300,000	8,900,000
LD Total	26,000,000	27,000,000	28,800,000

K. OFFICE OF HUMAN DEVELOPMENT SERVICES

ADMINISTRATION ON DEVELOPMENTAL DISABILITIES

The Administration on Developmental Disabilities (ADD) of the Office of Human Development Services is responsible for administering the Developmental Disabilities Act of 1984 (Public Law 98-527). The mission of this Act is to maximize the independence, productivity, and community integration of persons with developmental disabilities by assisting States to assure that these individuals receive appropriate care and services, and that each State has a system to plan, coordinate, monitor, and evaluate services to protect their legal and human rights. Additionally, the ADD supports 42 University-Affiliated Facilities and Satellite Centers responsible for training professionals, providing exemplary services and technical assistance, conducting research, and disseminating information for persons with developmental disabilities.

Developmental disabilities are defined as severe, chronic disabilities attributed to mental or physical impairments manifested before age 22, which cause substantial limitations in at least three areas of major life activity and result in the need for services over an extended period of time. Limitations can be in the areas of: self-care; receptive and expressive language; learning; mobility, self-direction; capacity for independent living; and economic independence.

Services for persons with developmental disabilities are often provided over an entire lifetime and can vary with the needs of the individual. The ADD strives to integrate persons with developmental disabilities into existing systems.

The Developmental Disabilities Act promotes the blending of funds with existing programs at the local level to enhance the provision of services to persons with developmental disabilities, as well as the use of seed money to help establish new or improved programs that will be expected to operate without these funds in the future. The limited money available to the States is used to help fill gaps in services.

Most developmentally disabled individuals receive the greatest benefit from different combinations of services at different points in their lives. The developmental disabilities program makes available a constellation of services by tapping into a variety of service agencies, nonprofit organizations, and private sector resources.

ACTIVITIES RELATED TO LEARNING DISABILITIES

Relatively few persons meet the severity and criteria for eligibility for services under this program. Thus, there are no major program activities funded by the Administration on Developmental Disabilities that are directed specifically to the learning disabled population at either State or local levels. Protection and advocacy agencies occasionally represent individual learning-disabled clients (who qualify under the functional limitation criteria) in their right to obtain an appropriate education. There are no data on the number of learning disabled persons served for Fiscal Years 1985 or 1986 since they would not meet program funding criteria. Individuals who may be developmentally disabled and have a learning disability are served on the basis of their developmental disability. Consequently, no meaningful data on expenditures are available.

L. ENVIRONMENTAL PROTECTION AGENCY

The mission of the Environmental Protection Agency (EPA) is to protect public health and the environment from the adverse effects of pollution. The EPA is a regulatory agency responsible for establishing and enforcing environmental standards specified in statutes enacted by Congress, and conducts and supports research on toxicology as well.

Evidence that certain chemicals attack the nervous system and produce disabling behavioral and neurological disorders (including effects on learning and memory) has resulted in a recognition of the need for neurotoxicological data. This need has been expressed in various environmental laws, which guide EPA's research and development program. Although learning disabilities caused by toxicant exposure either to adults or to the very young are not specifically mentioned in these laws, they are considered an adverse health effect and are addressed in both the EPA's intramural and extramural research programs.

The focal point within the EPA for planning, conducting, coordinating, and evaluating a program for studying the effects of physical and chemical agents on nervous system function is the Neurotoxicology Division (NTD) within the Health Effects Research Laboratory, Office of Health Research. Included in this research are studies related to toxicant-induced changes in learning and memory. In Fiscal Year 1987, neurotoxicological research received less than one percent of the total research and development budget.

To examine thoroughly the toxicant-induced changes in nervous system function, scientific investigation in the neurotoxicology program proceeds at all levels of neural organization, including functional and structural. In developing the necessary multidisciplinary approach to the study of neurotoxicology, the NTD's overall program strategy stresses both short-term needs, such as toxicology testing on relevant environmental chemicals, and long-term goals, including development of methods to detect and characterize neurotoxic effects, assessments of hazard due to exposure, and establishment of methods to extrapolate animal data to human populations. Within the framework of this strategy, five overall objectives have been identified. These are: (1) methods development and validation, including evaluation of existing methods, design and evaluation of new methods, and development of testing strategies; (2) neurotoxicological evaluation (studies of the neurotoxicity of heavy metals, pesticides, and hazardous air pollutants); (3) determinations of the significance of neurotoxicological indicators for assessing risk in humans; (4) developmental neurotoxicology (behavioral teratology), which evaluates the effects of perinatal toxicant exposure on the development of the nervous system, including the potential of developmental exposures to produce learning disabilities; and (5) studies of mechanisms of action.

PROGRAM HIGHLIGHTS AND ACCOMPLISHMENTS

To address adequately the multidisciplinary demands of the program, the NTD research effort has been divided into four program areas: behavioral toxicology, neurophysiology, neurochemistry, and neuropathology. These areas provide the necessary diversity of approaches required to address the problems of potential neurotoxicity. The approach most related to learning disabilities is behavioral toxicology.

- Since the establishment of the NTD in 1978, several methods have been implemented for quantitatively evaluating behavioral change. These methods include several tests of motor activity and coordination, learning and memory, schedule-controlled operant performance and sensory function. Collectively, these tests broadly sample the major classes of behavior that are both closely associated with nervous system integrity and crucial for insuring the survival of organisms. Considerable data have already been collected on the acute effects of a wide variety of pesticides, heavy metals, several parameters of nonionizing radiation, selected psychoactive drugs, cytotoxic chemicals, and solvents. Subchronic exposure studies have also been made of selected chemicals. Results of these studies have collectively shown the utility of various behavioral tests for detecting and characterizing toxicant-induced dysfunction. Some progress has also been made in evaluating the relative sensitivity of several of the most widely used behavioral tests in screening for toxicant-induced behavioral change, including learning disorders.

- High priority is currently being placed on assessing the neurobehavioral effects of different toxicants on multiple measures of behavior. Results will enable drawing conclusions about the comparative sensitivity of the various behavioral tests as well as better characterization of overall neurotoxic properties. These studies evaluate the effects of exposure both in adults and in developing organisms.

- Limited progress has been made in determining the behavioral effects of toxicant exposures in multiple species. Most work has focused on species differences in the ability of organophosphates to induce a dying-back neuropathy. These studies have relied primarily on qualitative clinical evaluations of the motor competence of hens, pigeons, quail, partridges, mice, rats, dogs, and sheep following either acute or subchronic exposure to triorthocresylphosphate and to leptophos. These studies have shown that there are substantial species differences associated with organophosphate-induced motor dysfunction. A few studies have also compared the effects of the formamidine pesticide, chlordimeform, on the behavior of mice, rats, and pigeons. Studies to evaluate the effects of lead exposure on cognition of children have been completed and are being followed up by more extensive studies in nonhuman primates.

- A small but ongoing program is focused on evaluating the effects of toxicants on the developing nervous system. These studies will serve as the basis for drawing conclusions regarding the likelihood of the age-dependent neurobehavioral toxicity of chemicals. In addition, behavioral evaluations have been undertaken in adult rats following perinatal exposure to toxic chemicals. The results indicate that toxic chemicals may often produce effects in neonates (including learning impairment) that not only persist well into adulthood but also differ dramatically from the effects produced when adult rats are exposed to the toxicants.

OPPORTUNITIES AND NEEDS

- The development of tests to provide for the early detection of neurotoxicity is a basis for a long-term strategy for the prevention of learning disabilities. Methods must be refined that can be used, according to a well-defined strategy, for screening new and existing chemicals for their neurotoxic potential. These studies must compare the neurotoxicity of chemicals on simple (motor activity, functional observational battery) and complex (learning and memory) tests of behavior in order to determine the predictive power of the screening tests. This work will also entail comparisons of the effects of chemicals on several different measures of behavior in order to reduce redundancies in the number of tests needed to comprehensively evaluate a chemical for its neurobehavioral effects. These studies will provide objective quantitative data on the effects of toxicants on different types of behavior. The data will supplant casual observations of the clinical condition of animals that laboratory technicians often are required to make.

- Efforts need to focus on collecting data on the acute and subchronic effects of chemicals that are members of a common class. Comparisons can then be made between chemical structure and behavioral outcome. This type of data is crucial for establishing structure-activity relationships that can be used for making preliminary judgments regarding either the potential of new chemicals for producing neurobehavioral toxicity, or the potential of older chemicals whose uses and production patterns increase.

- The adequacy of laboratory tests of animal behavior must be evaluated in terms of their power for predicting human neurobehavioral toxicity. Efforts must therefore be made to collect cross-species data on the neurobehavioral toxicity of chemicals and to compare, wherever possible, the effects of toxicants on animals and effects on humans under formally comparable conditions of laboratory testing.

- Exposure to a chemical could produce damage to the nervous system that may not be manifested as overt behavioral change, such as subtle changes in cognitive ability. Alternatively, termination of exposure may result in residual deficits that would no longer be apparent in the behavior under investigation. Efforts must therefore be made to identify these "silent" forms of toxicity through the use of pharmacological and environmental challenges. Comparison of the effects of prototype chemicals in previously toxicant-exposed and unexposed organisms may shed light on the underlying cellular mechanism(s) of neurotoxicity.

- Considerable efforts must be devoted to determining the behavioral consequences of well defined damage to the nervous system brought about by exposure to neurotoxic chemicals. In this regard, behavioral studies of cognition will be very important in understanding the neural basis for learning and memory. This work will aid in establishing an array of behavioral tests for neurotoxicity that have minimal overlap and that can be used for defining structure-activity relationships.

EXPENDITURES

Funding provided by the EPA for support of research on learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (est.)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific		--		--		--
LD-Related	3,198,886	(31)	3,742,655	(33)	2,259,898	(27)
LD Total	3,198,886	(31)	3,742,655	(33)	2,259,898	(27)

M. DEPARTMENT OF EDUCATION

OFFICE OF SPECIAL EDUCATION AND REHABILITATIVE SERVICES

Within the Department of Education, the Office of Special Education and Rehabilitative Services (OSERS) has made the study of learning disabilities an item of highest priority in Fiscal Years 1986 and 1987. The three components within the OSERS--the Office of Special Education Programs, the National Institute on Disability and Rehabilitation Research, and the Rehabilitation Services Administration--fund research and services for adults and children who have learning disabilities. Training of professionals who work with the population is also supported by the three agencies. In addition, there are both research and training activities targeted at families whose children and adolescents have a learning disability.

ACTIVITIES RELATED TO LEARNING DISABILITIES

The Office of Special Education Programs (OSEP) has the mission of assuring the free, appropriate public education of all handicapped children, as stated in the Education of the Handicapped Act, as amended. Over the past eighteen years, services for students with learning disabilities have increased markedly. Current data collected under the Education of the Handicapped Act-Part B indicate that 42.8 percent of identified and served handicapped children are classified as having specific learning disabilities. There were 1,872,399 children classified as having specific learning disabilities in the 1985-1986 school year.

Within the OSEP, the Divisions of Innovation and Development, of Educational Services, and of Personnel Preparation have the major responsibilities for learning disabilities research and training activities. These activities are for children and adolescents in preschool to postsecondary educational programs, both in special education classes and in regular education classes. Training includes preservice programs for undergraduates who are enrolled in colleges of education as well as inservice programs for regular and special educators who teach students with learning disabilities. In addition, the OSEP provides technical assistance to State educational agencies to enhance the capacities of local agencies to provide a variety of instructional options and screening procedures before children with learning problems are placed in special education classes.

The Division of Assistance to States, also with the OSEP, is responsible for monitoring the plans that each State is required to submit in order to receive Federal funds for special education programs. This Division collects data regarding the numbers of children classified in separate disability categories and ensures that services are provided in appropriate, least restrictive environments.

The National Institute on Disability and Rehabilitation Research (NIDRR) provides support for a comprehensive research program for improving the daily functioning of persons of all ages who have disabilities. Research and training activities in the area of learning disabilities focus on social skills development, vocational rehabilitation needs, and educational development of the population with severe learning disabilities. In these studies, an emphasis is on the importance of involving the family of the learning disabled person in all aspects of that person's educational and rehabilitative programs. Research activities currently sponsored by the NIDRR include developing and evaluating strategies that will enable families to teach appropriate social skills to their children who have severe learning disabilities. In addition, the vocational rehabilitation needs of adults with learning disabilities are being studied. The NIDRR is bringing together a group of experts to discuss the development of a model training curriculum for vocational rehabilitation counselors who work with clients who have learning disabilities.

Another NIDRR-supported activity is determining the incidence and prevalence of learning disabilities as defined by an ability and achievement discrepancy in children up to the third grade. This longitudinal study will also identify, assess, and evaluate the characteristics that distinguish children defined as learning disabled by operational criteria from those who do not meet the criteria yet who are not succeeding in elementary school.

The Rehabilitation Services Administration (RSA) provides grants to States to conduct comprehensive vocational rehabilitation programs that meet the "needs of handicapped individuals so that such individuals may prepare for and engage in gainful employment..." In 1981, for the first time, individuals with learning disabilities were listed as a separate category of persons eligible for vocational rehabilitation services. This new classification and definition of learning disabilities was the direct result of a Special Task Force on Learning Disabilities, which was convened by the RSA Commissioner in 1980. This task force has been reconstituted and met twice in 1986. One of the new task force's charges is to develop a definition of severity of learning disabilities to ensure that persons who are severely disabled because of learning disabilities will be served, even if a State does not have funds to serve all eligible handicapped persons and has to implement an order of selection system.

While the HRSA does not support research, it does support extensive training activities for vocational rehabilitation counselors and related services personnel. These activities include developing new vocational techniques and approaches used by counselors in order to enhance the successes of clients with learning disabilities. In other projects, efforts are being made to improve the level of diagnostic and psychological consultation services of psychologists who work for State vocational rehabilitation agencies. There are also projects that provide rehabilitation counselors with multidisciplinary training to improve their skills in working with clients who have learning disabilities.

PROGRAM HIGHLIGHTS AND ACHIEVEMENTS

The Department of Education is able to report on several accomplishments in the area of learning disabilities. Given the fact that a learning disability is a lifelong situation, the OSERS is concerned with the long-range research, training, and service delivery needs of persons of all ages with learning disabilities, to ensure that persons with learning disabilities will be able to go to school, work, engage in recreational activities, and live as independently as possible in their communities in integrated, nonrestrictive activities. Two of the accomplishments for children and adults with learning disabilities are described below.

In 1969, only 120,000 students were classified by public schools as "learning disabled." Eighteen years later, that number rose to 1,872,399 students, or 4.78 percent of the total school-aged population between the ages of 5 and 17. Because of this dramatic increase, the Office of Special Education and Rehabilitative Services has made the study of learning disabilities an item of highest priority for Fiscal Years 1986 and 1987. This priority is known as the General Education Initiative for Learning Disabilities, and is one of the OSERS's major accomplishments in this field.

The OSERS priority addresses the need for research and training to improve the identification, classification, and placement procedures used with students who have learning disabilities. From State to State and from school district to school district, there are great discrepancies in the criteria used for determining eligibility for placement in special education programs. In addition, State and local education agencies have had great difficulty in trying to develop an operational definition of learning disabilities.

Quite often the inconsistent identification, classification, and placement procedures used with students with learning disabilities result in erroneous educational decisions. Recent data indicate that of the 39 million students in public schools, approximately 11 percent or 4,373,000 are eligible for special education services for various handicapping conditions under State or Federal legislation. Studies have also indicated that an additional 10 percent to 20 percent of the children in school may not be eligible, but still have mild to moderate learning and behavior problems that impede educational progress. Therefore, it is estimated that about 7,800,000 students may be having learning problems.

In an attempt to gather and exchange information, several meetings of parents, researchers, educational experts, and Federal personnel were convened in 1985 and 1986. The participants focused on the problems that schools face in trying to meet the educational needs of students with learning disabilities. The groups also looked at the needs of students with learning difficulties, regardless of whether the students are in special education, regular education, Chapter I, or bilingual programs.

These meetings also revealed that State and local education agencies frequently have difficulty in appropriately identifying and placing students with learning disabilities and learning problems, which are exhibited by their failure to benefit from and achieve in regular education programs. Many of these children may be misclassified and be receiving special education services.

It also became evident that there was a need for improved identification, teaching, and funding models to appropriately educate students with learning disabilities and learning problems. By providing alternatives, schools that cannot provide compensatory or remedial services to failing students who are not eligible for special education will not inadvertently make the learning disabilities program the only option available. By the same token, alternatives will help to ensure that students who are in fact learning disabled will be appropriately identified and placed, while others, who are not learning disabled, yet may need similar teaching services, will not be inappropriately placed in classes for learning disabled students.

Thus, the General Education Initiative for Learning Disabilities emerged. It is geared toward expanding and improving special and general education services for learning disabled students within general education settings. This initiative also encourages the improved use of general education settings to meet the needs of children with learning problems who do not have a diagnosed disability. The findings of the previously mentioned task force have been compiled in a report to the Assistant Secretary for the Office of Special Education and Rehabilitative Services.

This report, Educating Students with Learning Problems--A Shared Responsibility, discusses the weaknesses in current approaches to the education of students with learning problems and suggests strategies for correcting these weaknesses. It also makes recommendations for strengthening the collaboration between special education and regular education programs. These recommendations have become the foundation for the ways in which the OSERS is looking at creative methods to benefit students with learning disabilities in regular education settings. The published findings of the task forces of parents and educators have provided the educational community with a blueprint for making major alterations in the ways in which services are delivered to students with learning disabilities. The end result should be more effective and more efficient programs for these students.

A second accomplishment focuses on the vocational rehabilitation needs of adolescents and adults with learning disabilities. In 1981, the Rehabilitation Services Administration designated "learning disabilities" as one of its eligibility codes, making it possible for persons with learning disabilities to receive State vocational rehabilitation services. So that vocational rehabilitation counselors and related services personnel are better able to work with this new population, the RSA has funded several training projects to improve the capabilities of these professionals. In addition, the RSA is examining ways in which families with learning disabled members can be more involved in rehabilitation programs.

In response to this RSA initiative, the National Institute on Disability and Rehabilitation Research funded a four-year study to identify the vocational rehabilitation needs of adults with learning disabilities. This was the first Federally funded study on this topic. Its objectives were to identify the range of vocational rehabilitation needs of adolescents and adults with learning disabilities; identify the barriers that prevent the population from receiving services; identify the factors leading to job attainment and maintenance; develop and evaluate a diagnostic battery for adults; and evaluate training materials geared for different learning styles.

This soon-to-be-completed project has found that one of the greatest barriers to the provision of services is the fact that persons with learning disabilities, family members, and teachers do not know that the services exist. The project's findings also indicate that employers do not understand the disability but that they would like more information. In addition, employers said that the lack of appropriate behaviors, such as arriving at work on time, controlling one's temper, and completing a task, are the biggest barriers to job maintenance. In the spring of 1987, the project staff will hold a national conference at which time they will discuss their major findings. They will also make recommendations for improving services, improving the dissemination of information about the availability of services, and improving the dissemination of information about learning disabilities to potential and actual employers. Future research and training recommendations will also be presented.

OPPORTUNITIES AND NEEDS

The Office of Special Education and Rehabilitative Services has identified several areas for increased research emphasis.

- Early detection and remediation of learning disabilities in very young children will be of interest. The new amendments to the Education of the Handicapped Act mandate early intervention services beginning at birth, making it possible for predictors of learning disabilities to be studied and remediation strategies developed and evaluated.
- Further study and refinement of the General Education Initiative will be of highest priority.
- Improved programs and models for providing services to adolescents who are making the transition from special education programs to the world of work will be developed and evaluated. This includes the development and evaluation of supported work models for youth and adults with severe learning disabilities.

EXPENDITURES

Funding provided by the DOE for learning disabilities is as follows:

	FY 1985 (actual)		FY 1986 (actual)		FY 1987 (est.)	
	$	(No.)	$	(No.)	$	(No.)
LD-Specific	6,089,962	(69)	11,126,033	(137)	12,233,026	(152)
LD-Related	--		--		--	
LD Total	6,089,962	(69)	11,126,033	(137)	12,233,026	(152)

IV. ASSESSMENT OF THE NUMBER AND CHARACTERISTICS OF PERSONS AFFECTED BY LEARNING DISABILITIES*

The mandate from Congress to the Interagency Committee on Learning Disabilities directed that the Committee include in its report an estimate of "the number of persons affected by learning disabilities and the demographic data which describes such persons." To fulfill this charge, the epidemiologic and survey literature on learning delay and learning disabilities was reviewed, and the number of persons identified and served as learning disabled in the public school system was ascertained. Consideration of this charge requires an understanding of the concept of prevalence and of the importance of the definition of learning disabilities that is used.

THE CONCEPT OF PREVALENCE

Prevalence is the number of persons with a particular condition in a particular population at a particular time. Prevalence may vary when (1) different case definitions of the condition are used, (2) different populations are studied, or (3) studies are done at different ages or different points in time.

The reported prevalence of learning disabilities varies from 2 percent to over 20 percent (Broman, 1985). Many case definitions have been employed in different studies, and at present there is still much controversy about which case definition should be used (Adelman, 1986; McNutt, 1986). The different case definitions reflect the changing concepts of learning disabilities as they have evolved over the last several decades.

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* This section is based on a report prepared for the Committee by Myron J. Adams, Jr., M.D., and Marshalyn Yeargin-Alsopp, M.D., of the Division of Birth Defects and Developmental Disabilities, Center for Environmental Health, Centers for Disease Control.

Because the definition of and diagnostic criteria for learning disability have not been standardized, consistency in the design of prevalence studies has not been maintained. Accurate time trend analyses therefore are not possible.

DEPENDENCE OF PREVALENCE ON THE DEFINITION USED AND ON DIAGNOSTIC ACCURACY

The case definition used and the method of case ascertainment are major determinants of the magnitude of prevalence found in a given study. Case definitions are generally based on measures of discrepancy in performance in order to include potential cases, and measures of more specific conditions are then used in order to exclude inappropriate cases. Criteria for both inclusionary and exclusionary measures of learning disability have not been standardized, however.

When discrepancy in performance is measured, prevalence increases as the number of performance areas measured increases. For example, a higher prevalence of learning disorders would be expected if listening, speaking, reading, writing, reasoning, mathematical, and social skills were all tested than if only reading skills were tested.

When discrepancy in performance is measured, the magnitude of discrepancy necessary for categorizing a person as "affected" may vary. A learning problem can be defined, for example, when a given skill (reading or reasoning) is below 80 percent of the mean of the general population, or when the skill is below 75 percent of the mean. The cutoff level below which a person is deemed affected by learning disability has not been standardized. Prevalence rates would be expected to be higher when the percentile cutoff level is 80 percent than when it is 75 percent.

Most definitions of learning disabilities have exclusionary criteria. The fewer the number of excluded conditions, the higher the expected prevalence rate. A cutoff level is also used for many of the exclusionary conditions. For example, if an IQ of 70 is used to define mental retardation as an exclusion, the expected prevalence would be higher than if the cutoff was set at an IQ of 80.

To further complicate the situation, the definition and concept of learning disability have changed over time. Learning problems among persons with normal aptitude or intelligence have been variously termed learning disabilities, specific learning disability, dyslexia, minimal brain dysfunction, hyperactivity, and attention deficit disorder (Broman, 1985).

The concept of learning disability was introduced in 1962 to define "a retardation, disorder, or delayed development in one or more of the processes of speech, language, reading, writing, or arithmetic resulting from possible cerebral dysfunction and/or emotional or behavorial disturbance and not from mental retardation, sensory deprivation, or cultural or instructional factors" (Kirk, 1962). The term "specific learning disabilities" has been used more recently to describe the specific performance area in which there is a discrepancy between achievement and intellectual ability. Examples of specific learning disabilities include oral and written expression, listening and reading comprehension, mathematical calculation, and mathematical reasoning.

The term "minimal brain dysfunction" was also introduced in the 1960s to describe "children of near-average, average, or above-average general intelligence with certain learning or behavorial disabilities ranging from mild to severe, which are associated with deviations of function of the central nervous system" (Clements, 1966).

Although hyperactivity is a symptom of minimal brain dysfunction, some investigators have focused on a specific syndrome manifested by excessive motor activity, distractibility, inattention, and impulsivity (Levine, 1980). Although hyperactivity is frequently associated with learning disability, hyperactivity and learning disability have been shown to be independent problems (Lahey, 1978).

In 1980, the diagnosis of attention deficit disorder, with and without hyperactivity, was included in the *Diagnostic and Statistical Manual.* Learning disabilities often, but not always, accompany attention deficit disorders (Rapoport, 1980).

Since no diagnostic marker for learning disability exists, it is a clinical diagnosis based largely on exclusion. P.L. 94-142 defined learning disabilities as follows:

> "Specific learning disability" means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.

This definition is the primary determinant of the number of students identified and served in public school programs for children with learning disabilities, and thus of any prevalence estimate based on persons served.

There has been no study based on a large representative sample using a standard definition in which (1) persons are identified as underachievers or learning delayed and (2) such persons are further studied to see which meet specific criteria for learning disability, such as those included in the definition in P.L. 94-142 or that proposed by the Interagency Committee on Learning Disabilities (see Chapter VI). Consequently, a valid survey-based estimate of the prevalence of learning disability is not available, and the ICLD is forced to rely on extrapolations from population-based studies that use different diagnostic criteria and from public education estimates of the numbers of persons served in learning disabilities programs.

POPULATION-BASED STUDIES

Different population-based studies and surveys have varied in both definition of learning disabilities used and methods for diagnosis. Most studies report persons with delays in school grade or delays in expected achievement for IQ level, without separating those delays due to learning disability from those due to other causes. The largest population-based studies include those of Myklebust (1969), Meier (1971), Rutter (1970a), Nichols (1981), and Shaywitz (1987). There has been little, if any, consistency in inclusionary and exclusionary criteria between studies.

In the Myklebust and Meier studies, detection of affected students was carried out in a two-phased process (teacher-administered screening followed by investigator examination of those detected in the screening phase). In both studies, several performance areas were tested. In the Myklebust study, which used two different cutoff levels for inclusionary criteria, prevalences of 15 percent and 8 percent were found. In the Meier study, a 12 percent prevalence was found.

The Rutter study focused on reading performance. Of the children screened, 3.7 percent had specific reading retardation. Reading retardation was defined by reading accuracy or comprehension at least 28 months retarded in relation to that predicted by age and intelligence. Students with an IQ that was 2 standard deviations below the mean were deemed to have intellectual retardation and were excluded from the reading disability group.

In the Nichols study, the diagnostic criteria were set not to provide consistency with any previous study criteria, but to provide a prevalence rate in a range that had come to be accepted (between 3 percent and 8 percent).

A more recent study of learning disability by Shaywitz and colleagues (1987) was population-based, and each child was tested individually. The definition used was based on Federal guidelines that indicate a discrepancy between ability and achievement. The prevalence of learning disabilities at the end of first grade was estimated as 11.0 percent with a standard error (S.E.) of 2.7 percent. At the end of the following year the prevalence of LD was 12.6 percent with an S.E. of 1.9 percent. Prevalence rates were also determined separately each year for reading LD and mathemathics LD. In the first grade, reading LD was 7.0 percent with an S.E. of 1.8 percent, and mathematics LD was 7.0 percent with an S.E. of 2.0

percent. The following year, the rates were reading LD, 7.3 percent (S.E. 1.8 percent), and mathematics LD, 7.5 percent (S.E. 0.5 percent).

PUBLIC EDUCATION ESTIMATES OF PERSONS SERVED

The U.S. Department of Education (1987) reports that 4.73 percent of all school-aged children receive special educational services for learning disabilities as defined by P.L. 94-142 (Table I). This percentage

TABLE I

Percentage of School Enrollment Served as Handicapped, by Handicapping Condition, during 1976-77, 1984-85, and 1985-86 for the 50 States and the District of Columbia a/

Handicapping Condition	1976-77	1984-85	1985-86
Learning disabled	1.79	4.72	4.73
Speech impaired	2.84	2.90	2.86
Mentally retarded	2.16	1.84	1.68
Emotionally disturbed	0.64	0.96	0.95
Other health impaired	0.32	0.18	0.17
Multihandicapped b/	--	0.18	0.22
Hard of hearing/deaf	0.20	0.18	0.14
Orthopedically impaired	0.20	0.15	0.14
Visually handicapped	0.09	0.08	0.07
Deaf-blind b/	--	0.01	0.01
Total	8.24	11.19	10.97

a/ The percentages represent children from birth to age 20 served under Chapter I of The Education Consolidation and Improvement Act (State Operated Programs) and children aged 3 to 21 years old served under the Education of the Handicapped Act, Part B, as a percentage of the students enrolled in prekindergarten through grade 12.

b/ Data for these categories were not collected for 1976-77.

Adapted from U.S. Department of Education: Ninth Annual Report to Congress on the Implementation of the Education of the Handicapped Act, 1987.

represents almost 1.9 million children. Individual school districts have the prerogative to establish their own inclusionary and exclusionary cutoff criteria. A school district using more stringent criteria for learning disabilities, therefore, would be expected to report a lower prevalence rate than one using less stringent criteria. It is not possible to ascertain at this point whether changes in prevalence rates reflect changes in criteria and services available or actual changes in prevalence, although the former is considered more likely.

CHARACTERISTICS OF PERSONS WITH LEARNING DISABILITIES

Important variables that influence the prevalence in a population include socioeconomic status and sex. Poor socioeconomic circumstances is a strong predictor of learning disabilities (Alberman, 1973). Learning disabilities, by most definitions used, are at least twice as common among boys as among girls (Broman, 1985). Most studies of the prevalence of learning disabilities have been of preadolescent populations. The few followup studies of affected children suggest that most continue to have related problems as adolescents and young adults (Gittelman, 1985).

Although the associations between learning disabilities (by most definitions) and low socioeconomic status and male sex have been consistently found in the larger population-based studies, associations between other, more etiologically related factors have been assessed primarily only in small studies of selected populations. Etiologic factors, when established, may become the basis for exclusion according to some definitions of learning disability. For example, sensory impairments such as hearing or visual handicaps are causes of learning problems in persons with normal aptitude and intelligence, yet this group of conditions is excluded in most case definitions. Nonetheless, if delayed learners are not tested for these impairments, such children may be incorrectly included with those classified as learning disabled. Some of the reported characteristics associated with learning problems are noted below, regardless of whether they might be exclusionary criteria in some definitions of learning disabilities.

Genetic factors have been reported to be important predictors in some cases of learning problems in persons with normal aptitude and intelligence. Boys with an extra Y chromosome and girls with only one X chromosome have unique learning problems (Hier, 1980; Pennington, 1982; Alexander, 1966). Family, twin, and foster rearing studies further support a genetic etiology in some cases (DeFries, 1978; Broman, 1985).

Reports show learning problems to be associated with very low birth weight (Eilers, 1986; Sell, 1985) and with seizure disorders (Rutter, 1970b; Stores, 1976; Corbett, 1983). Evidence is less clear documenting an association with lead exposure (Bellinger, 1983; Gittelman, 1983), head trauma (Chadwick, 1981; Shaffer, 1975), and prenatal maternal alcohol abuse (Hesselbrock, 1985).

CONCLUSION

In the absence of good prevalence data, the Committee believes that 5 percent to 10 percent is a reasonable estimate of the percentage of persons affected by learning disabilities. It is clear that prevalence is somewhat higher among socioeconomically disadvantaged populations, and higher in males than in females.

Further study is necessary to provide an accurate estimate of the prevalence of learning disabilities in this country. Such an endeavor should not be undertaken until there is a national consensus on a definition of learning disabilities, and inclusionary and exclusionary criteria have been agreed upon and standardized. When these goals have been met, the Committee recommends that a sufficiently large study be carried out to determine the actual prevalence of learning disabilities, in which students are individually tested, and those who are found to have learning problems are further evaluated in order to discover underlying etiologies, some of which may differentiate those with learning disabilities from those whose learning delay is due to other causes. This recommendation is presented with greater detail in Chapter VI, "Diagnosis."

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V. REVIEW AND DESCRIPTION OF RECENT RESEARCH ON THE CAUSE, DIAGNOSIS, TREATMENT, AND PREVENTION OF LEARNING DISABILITIES

The National Conference on Learning Disabilities, cosponsored by the Interagency Committee on Learning Disabilities and the Foundation for Children With Learning Disabilities, and held in January 1987, focused on current research findings in five areas: Neurobiology of Learning and Memory; Specific Developmental Disabilities of Reading, Writing, and Mathematics; Developmental Language Disorders; Social Skills Deficits; and Hyperactivity/Attention Deficit Disorder. The Conference, which was chaired by the Director of the National Institute of Child Health and Human Development, attracted over 600 attendees.

For each topic, an expert consultant commissioned by the Committee presented a review and description of recent research in that field as related to the cause, diagnosis, treatment, and prevention of learning disabilities; identified gaps in knowledge; and made recommendations for future research. Each presentation was critiqued by expert discussants, and followed by discussions with the Committee and with members of the audience. The full texts of these literature reviews of recent research findings are contained in the Appendix volume of this report (printed separately). Summaries of the literature reviews and of the National Conference and Committee discussions of these five topics follow. Although the Committee is in agreement with many of the recommendations made in these summaries, the Committee's recommendations to Congress are given in Chapter VI.

A. NEUROBIOLOGY OF LEARNING AND MEMORY*

Learning is one of the primary characteristics that defines human beings as human and distinguishes them as individuals. The loss of this ability in children touches everyone deeply, and is a major national problem. It is appropriate, then, that the biomedical sciences should be concerned with the nature of the machinery in the brain that processes memory and how that machinery becomes disrupted by genetic errors, disease, and pathology. It is a problem that impacts on all ages, but nowhere more tragically than with children.

The major questions being addressed by research on the neurobiology of learning and memory are the following:

- Is learning a single phenomenon or can it be subdivided, and are these categories similarly impacted by learning disabilities?
- What is required of a neurobiological explanation of learning, and what answers do we require?
- What is the state of science today, particularly relative to childhood learning disabilities?

LEARNING AND ITS SUBTYPES: SELECTIVE VULNERABILITY

Learning may seem to be a single phenomenon, but it is now clear that there are at least two general categories: procedural, skill, or rule memory (typing, bicycle riding, linguistic syntax), and fact or declarative memory (faces, names, semantic aspects of language).

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* The main source for the information on research accomplishments summarized in this section was a literature review prepared for the Interagency Committee by Carl W. Cotman, Ph.D. Dr. Cotman's full review is included in the Appendix to this report.

These distinctions are important because neuropsychological studies over the past ten years have shown that pathology can and often does affect memory in a selective fashion. Learning of fact memories appears to involve different, more easily disturbed, brain systems than those subserving skill memory.

Three levels of neurobiological description are needed for any explanation of learning:

- Key brain regions: the location of those regions in the brain associated with the storage, retrieval, and processing of different types of memory.
- Memory "circuits" in brain: the characteristics of the circuitries contained within learning-related brain structures and how these characteristics are linked to the phenomenologies observed at the other levels of analysis.
- Synaptic mechanisms: the nature of the stable modifications that actually encode memory, and the types of mechanisms that produce those modifications.

The study of memory is a great challenge, perhaps the greatest in biological science. Memory involves changes in a tiny fraction of an extremely large pool of elements, a conclusion that makes the task of finding those changes using current technologies formidable. What can be done about this roadblock to neurobiological investigation of learning? One response that has become particularly productive in recent years is to study learning or learning-like phenomena in relatively simple "model" systems. The idea is to extract basic principles from these models in which molecular and anatomical details can be studied, and then to use them in analyzing learning in the higher regions of the brain.

THE KEY BRAIN AREAS IN MAN AND PRIMATES

What are the key brain areas in man's "memory" circuits? The knowledge of memory formation in humans is based largely on the study of human amnestic syndromes. Amnesia is characterized by an impaired ability to acquire new information and by difficulty remembering at least some information that was acquired prior to the onset of amnesia. At least two areas of the brain appear to be critical to memory formation, the medial temporal lobe region and subdivisions of the thalamus. Considerable insight has been obtained through the study of a small number of individuals in which severe anterograde amnesia (inability to learn new things) has occurred in the absence of other cognitive deficits.

In 1953, the patient "H.M." received a bilateral resection of the medial temporal lobes in an effort to relieve severe epileptic seizures. Since that time, he has been unable to learn new facts and forgets daily events almost as fast as they occur. For example, H.M. cannot learn a list of words, even after many repetitions, and is unable to recognize faces he has seen many times over the past 30 years. His memory deficit extends to both verbal and nonverbal material, and involves information acquired through all sensory modalities.

However, despite H.M.'s inability to store new information in the form of factual data, his ability to develop perceptual-motor skills appears to be normal. For example, H.M. successfully learned a mirror tracing task and a complex cognitive puzzle at a rate comparable to controls. His speed and accuracy increased in spite of the fact that he had no recollection of having previously performed the tasks.

Thus, different brain structures appear essential for fact vs. skill memory. This information suggests that the processes which underlie the formation of these two types of memory are functionally and anatomically distinct, and that medial temporal lobe and middiencephalic structures are involved specifically with fact memory processes.

Primate studies using select lesions and anatomical tracing methods also provide evidence for two fundamentally different, anatomically distinct, memory systems. Primate models suggest that severe temporal lobe amnesia will result only following the combined destruction of both the hippocampal formation and amygdala; destruction of either structure alone produces either a small deficit (hippocampus) or no deficit at all (amygdala). This system serves in the formation of fact memories, appears to utilize a specific cortico-limbo-diencephalic circuit, and is the system thought to be impaired in patients with medial temporal lobe amnesia. This system and systems that serve other memory abilities mature at different rates.

BRIDGING THE GAP BETWEEN MAN AND ANIMALS: AN OLFACTORY LEARNING MODEL

The data from neuropsychological studies of primates and human amnesics demonstrate that memory formation processes can be localized to specific structures and circuits in the brain. Are there also rodent behavioral tests that sample simple forms of cognition-linked learning and that respond appropriately to lesions in the hippocampus, amygdala, and dorso-medial nucleus of the thalamus? For many reasons, most research is conducted on small animals, especially rodents. These animals have a sophisticated olfactory (smell) system compared to their other sensory systems. Recent data indicate that the learning of olfactory cues may be a reliable means to probe cognitive (fact) learning in rodents. In a sense, it makes use of the rodents' strengths and man's weaknesses to probe central memory processing systems in both.

Olfaction is a common language for animals and humans. Olfaction thus provides an opportunity for using rodents in the study of cognitive processes that are comparable in a very real sense to those experienced by humans. There are only two connections between the odor receptors in the nose and the temporal lobe, a key memory processing center. These anatomical features suggest that olfaction can be used to detect dysfunction in brain systems crucial to memory and cognition. In accordance with this suggestion, the patient H.M., who as noted earlier exhibits an anterograde amnesia resulting from damage to the hippocampus and surrounding structures, is profoundly impaired on even very simple smell identification tasks.

Odor memories in rodents appear to follow predictions of cognitive learning deficits in man. Fact memories in humans are acquired rapidly and stored in a system of enormous capacity; this information proved to be true for odor memories in rats as well. More important, lesions that separate the olfactory cortex from the hippocampus produced an anterograde amnesia which matched that seen in humans with hippocampal lesions. Thus the rats appeared to learn new odors when several exposures were closely spaced in time but then exhibited no memory of the training when tested one hour later. This amnesia does not include memories formed before the lesions, much in the way that patients with temporal lobe/hippocampal dysfunction retain the greater part of their preinjury memory store. These studies provide a very simple behavioral test that appears to measure a form of data memory that requires the hippocampus for encoding.

The extreme conservatism of the olfactory system raises the possibility that tests that detect damage or circuit dysfunction in rats might also be used in humans. Initial efforts have already yielded some interesting clinical results. The olfactory cortex is now thought to be one of the earliest sites affected by Alzheimer's disease. Tests found to be effective in detecting damage to the cortex in rats did indeed prove to discriminate patients thought to be in the early stages of Alzheimer's from age-matched controls. It would be intriguing to test subjects with learning disabilities on odor learning problems and determine if any deficits observed correspond to impairments found in rats with lesions or subjected to pharmacological manipulations. This is one illustration of a growing body of research on the study of fact memory in rodents.

What are the neural mechanisms involved in such higher forms of learning? Learning theorists generally assume that the actual encoding process involved particular patterns of activity acting upon a limited number of synapses resulting in a stable, perhaps structural, change in synapses. Do particular patterns of stimulation in fact produce the type of effects expected of a learning device? The answer is yes.

A SIMPLE NEURAL ANALOG OF LEARNING

In the hippocampus, a phenomenon called long-term potentiation (LTP) shows the properties expected of a learning mechanism. Recent studies have produced a remarkable picture of how LTP is induced and thereby provided a specific hypothesis on the origins of memory.

Brief periods (¼-1 sec) of high frequency stimulation delivered to pathways in the hippocampus cause an increase in synaptic strength (that is, LTP) that can last for weeks. This effect has the characteristics that make it an excellent candidate for the process through which some memories are formed.

The molecular mechanism involves a particular class of receptor molecules (the "NMDA receptors") that respond to the chemical transmitter used by hippocampal cells to communicate among themselves. When stimulated in a particular way, this system of receptors amplifies signals and leaves an extremely persistent "memory trace" in the form of anatomical changes. Many of the molecular events involved in this process are known and are now accessible to analysis. Knowing the complete mechanism should be possible within five years.

NMDA receptor distribution in brain may predict the organization of LTP in the brain. Autoradiographic techniques allow the study of these specific systems in human brain tissues obtained at autopsy. In the near future, these studies should be realized in vivo. The different steps will then be amenable to analysis in different learning disabilities.

LEARNING SKILLS: A DIFFERENT MECHANISM

The other major type of learning is skill or procedural learning. Studies of skill type learning have been under investigation for many years. In fact, historically the major initial breakthroughs in the neurobiology of learning came from studies on this type of learning.

The most is known about the mechanisms of a simple type of classical conditioning: learning to blink the eye in order to avoid a noxious puff of air to the eye when warned by a tone. It is the first example in the vertebrate brain where the basic circuitry has been completely defined and where the precise focus of memory storage (the elusive "engram") has been identified. This work is primarily that of R. F. Thompson and his associates.

Eyelid conditioning exhibits the same basic laws of learning in a wide range of mammalian species, including humans, and is prototypical of classical conditioning of striated muscle responses. The circuitry necessary for learning and storage of this behavior is known. The engram (or storage site) lies in an area associated with the cerebellum. The cellular and molecular mechanisms await discovery now that the site(s) have been identified. It remains to be determined what other training paradigms will share common features of this circuit.

THE SYNAPTIC MECHANISMS: INVERTEBRATES PAVE THE WAY

It is, of course, difficult in these and related paradigms, to completely elucidate the biochemical mechanisms underlying classical conditioning. For this, the major advances have come from the invertebrates. The first detailed understanding of the mechanisms of learning at a cellular and molecular level came from these simple systems, which showed that the problem was solvable and gave many leads which were subsequently followed in higher systems.

What are the molecular mechanisms of classical conditioning in invertebrates? And do they predict mechanisms for vertebrates? The most complete studies are of Aplysia Californica, the sea slug, pioneered by Eric Kandel and his associates. This animal has the advantage of having so few neurons that the circuitry can be traced in detail. The individual cells are readily identified and have even been named, e.g., R1, R2, etc. Learning appears to take place at a defined set of synapses, where the molecular mechanism has been worked out to a degree unprecedented for other systems. It involves an increase in cyclic AMP, the phosphorylation of select proteins, and a decrease in the potassium currents. The decreased potassium current increases the duration of the action potential, causing a larger output of neurotransmitter.

Similar biophysical and biochemical mechanisms have now been observed in rabbit hippocampus following classical conditioning of the eye blink. That is, there is a reduction of postimpulse after hyperpolarization (AHP) measured in pyramidal cells that lasts for at least 1-2 days, exactly as predicted from invertebrate studies.

LEARNING MECHANISMS IN THE DEVELOPING BRAIN

Are these the same mechanisms used in the developing and adolescent brain? Specifically, in early development when circuitry is forming, does learning and environment have an impact on the formation of the brain's networks? The answer is yes. The central conclusions can be illustrated by two examples of impact of early experience on brain structure: early learning in the olfactory system, and experience in development of the visual system.

Early olfactory experience determines one of the many routes by which the normal olfactory brain will develop. Neonatal rodents, like babies, learn to prefer the odor of their mother when the odor is experienced with appropriate tactile stimulation. The number of select groups of cells and their connections in the olfactory bulb permanently increase. NMDA receptors and therefore neural activity appears to mediate this process. This effect is restricted to the first week of life.

There are several implications of this work. It means that an early learning experience is permanently etched into the circuitry of the central nervous system (CNS), which will bias the type of response to such future situations. In other words, do early experiences produce long-lasting changes in neural circuitry that affect subsequent behaviors? From animal studies, the answer is yes.

A minimum level of normal stimulation is also required for the visual brain to develop along its single normal path. For example, children may permanently lose vision in one eye if vision is temporarily impaired by eye injury early in life, even if the damage to the eye itself heals completely. The nature of the needed visual stimulation has the formal characteristics of a learning situation. It is an activity-dependent process that produces long-lasting change in cortical structures.

Visual stimulation is effective only in organizing the system if attended to or recognized by the brain by means of coincident nonspecific arousal. Both acetylcholine and norepinephrine appear to mediate the contribution of the nonspecific arousal system in specifying how visual stimulation will affect the organization of the cortical response to subsequent visual stimulation.

These findings indicate that the normal pattern of visual system development depends on a specific coincidence of visual stimulation and arousing stimulation. An abnormal pattern of visual system organization occurs if either aspect of this early experience is not present. The implication of these findings is that the developing brain circuitry registers environmental signals when the nonspecific arousal system places significance to the events.

RELATION TO LEARNING DISABILITIES

From the preceding sections, it is clear that the cellular and molecular substrates of learning are accessible to analysis in several vertebrate and invertebrate systems and that excellent progress is being made.

What are the possible neurobiological causes of learning disabilities? Clearly, learning depends on the proper operation of defined circuits that transfer the information and ultimately store it in a form accessible for retrieval. The substrate often appears to involve molecular changes in existing connections, or as more recent data indicate, actual formation (turnover) of new synapses.

What are the steps where learning has "weak links"? Neuropsychologists have amply documented the crucial roles played by general body and brain states such as arousal, motivation, attention, etc. Learning does not occur without a prior focusing of attention and without appropriate motivation. Deficiencies in these states can be expected to have powerful consequences on early learning abilities, and it is likely that disturbances do occur. Perturbations in the machinery that controls arousal, for example, are not uncommon in children and are often present as a hyperkinetic syndrome. Brain states are also known to exert a powerful influence over the body's endocrine system, and hormone levels in turn have been linked to the strengths of the memory trace.

Understanding how brain states variably interact with the learning process and finding ways of detecting (and correcting) disturbances are areas in which neurobiological research should be encouraged. Thus, for example, the so-called "conditional" transmitters, such as acetylcholine and norepinephrine, may not carry information content. These and related systems probably represent neural substrates of arousal and motivation, and act with specific circuits to produce memories. As more information is collected, it should be possible to define optimal levels of catecholamines, acetylcholines, etc., for the production of synaptic modification. This in turn should help the development of diagnostics and guide the development of appropriate interventions where needed.

Another logical candidate for a cause of learning disabilities is a perturbation of the machinery that produces specific brain rhythms and patterning of neural activity. The now-demonstrated connection between activity patterns and synaptic modification suggests that analysis of brain waves could be useful in the search for the causes of learning disabilities.

Perhaps the most obvious candidate for a cause of learning disabilities is in the chemistry that encodes experience into memory. The recent discoveries of receptors that are vital to storage and processing and the formulation of hypotheses involving specific enzymes open the way to exploring the possibility that errors in these mechanisms are responsible for disability. NMDA receptors are involved in early visual experience, early olfactory learning, adult learning, and long-term potentiation. Perhaps these receptors are abnormal in learning disabilities.

Damage to various brain circuitries is another possible cause of malfunctioning. Functional changes occur not only because of the loss of cells but also because damage to one or more critical elements during the development of a memory circuit will initiate the reorganization of residual circuitry. Undamaged neurons, for example, sprout and replace the connections lost by a process known as axon sprouting or reactive synaptogenesis. Sometimes this effect is beneficial; other times, harmful. Ultimately, it is necessary to correlate learning disabilities to injury in specific areas in humans where parallel animal models exist.

Finally, an environment rich in learning and training experiences can have an impact on brain structures. The most dramatic impact is during development, but the effects persist in many cases even into adulthood. Neuronal branches increase, for example, when an animal is trained for several weeks to reach for food with its new preferred paw.

Can learning disabilities be corrected? Several manipulations appear to offer promise for improving learning in animal models where there are defined neurological deficits. One powerful intervention has been the use of transplanted neurons. In many cases, this intervention has served to provide an additional source of state-dependent transmitters such as acetylcholine. Thus, for example, select CNS neurons can be replaced by similar types of transplanted cells, with recovery from the specific functional deficits. These types of manipulations show that interventions are possible and give valuable information of the minimal requirements for improvement in function. They emphasize the critical role of "state" in brain cognitive function.

Recently, several growth factors, particularly nerve growth factor (NGF), have been identified, which can act on CNS neurons to stimulate their survival and growth. It has been shown that NGF will stimulate central cholinergic neurons and will facilitate behavioral recovery. In fact, a single administration during development causes hyperactivity of the cholinergic system. This may be the beginnings of new levels for possible interventions.

CONCLUSION

Over the last five years, research on the mechanisms of learning has progressed dramatically. Recent work has focused on defining systems for analyzing relatively simple types of learning (sensitization, habituation, and classical conditioning) and for analyzing how physiological activity changes synapses. It is now clear that defined circuits exist for learning, that the site and location of the synaptic change can be localized, and that many of the specific biochemical mechanisms can be identified. Many of these approaches and conclusions need to be and can be applied to learning disabilities in children.

Many new tools are available to stimulate and capitalize on these advances. New imaging techniques will help bridge the gap between animals and humans. Computer networks are being built that simulate real brain networks, allow an examination of their properties, and predict where weak "links" exist. In fact, interest in computer models that simulate brain functions may be synergistic to the biological and cognitive sciences.

The study of learning and memory is in itself subtle and complex. It is truly multidisciplinary work requiring sophisticated behavioral analysis, systems analysis, and expertise in cellular and molecular biology. Inherent in approaches towards better understanding the neurobiology of learning disabilities is a need for coordinated investigations involving several levels of analysis. Such work needs to be fostered in the face of a steady trend toward greater specialization by neuroscientists.

SPECIFIC NEEDS AND OPPORTUNITIES FOR RESEARCH

- Implications from animal studies for learning disabilities in children need further evaluation. Several studies from the basic science literature have important implications for childhood learning disabilities. The normal development of the rodent brain, for example, depends on the proper environment. Animals reared in isolated environments during critical periods of development show irreversible abnormalities in brain circuitry. Do children with learning disabilities who become socially isolated develop more serious and more permanent learning disabilities? The human brain most certainly has critical periods, but almost nothing is known about them. When do they occur? The public needs information about the most critical times when children are irreversibly at risk.

- Better neuropsychobiological tests are needed. One of the many triumphs of recent research on learning and memory is the elucidation of specific brain circuits in learning and memory. Accordingly, tests can now be developed that probe the functional capacity of specific brain circuits in learning. These need to be refined for use on children in order to better understand the central deficits in brain function.

- Work on the chemistry of memory should be accelerated. It is not uncommon for scientific discoveries to go unappreciated for considerable periods of time; and enormous cumulative advances have been made in the understanding of the substrates of memory. These mechanisms need to be targeted for intense investigation, particularly during development. There has been very little research in this area.

- New animal models of cognition and cognitive disorders are needed. The studies summarized here have shown that animal models of human learning can be developed and used in the study of memory disorders. Efforts are needed that proceed in a more systematic fashion to discover behaviors and experimental manipulations in laboratory animals that reproduce specific aspects of human cognition and disease. In particular, there is very little basic work on learning and memory in animal models that would correspond to the ages 5-15 in developing children.

- Work on animals and man needs to be integrated. Overall, a working dialogue between scientists studying animals and humans is needed. New neuroimaging techniques including positron emission tomography (PET) scanning and magnetic resonance imaging (MRI) are only the beginning of the techniques which may play a key role in elucidating the central structures and studying them in humans. Detailed anatomical studies of postmortem tissues are also needed. Evaluation of pathology remains a highly subjective enterprise. An "electronic brain atlas" is needed that stores in a digital fashion the location, structural details, and variability of well-defined regions of the brain known to be at risk in pathology.

- Synergism between different levels of research should be encouraged. One mechanism for doing so is establishing research centers for learning disabilities. Future studies on the neural basis of learning disabilities must include several very different scientific disciplines. Work would be greatly stimulated if different levels of analysis were interconnected at the beginning of projects rather than attempting synthesis in a purely post hoc fashion. For example, attempts to develop animal models should be coupled with clinical work on children with disabilities. Serious consideration should be given toward establishing research centers especially designed for multidisciplinary studies and amelioration of learning disabilities in children. The centers concept, for example, has given new life and direction to the study of Alzheimer's disease as well as other fields. Centers ideally would infuse major new resources, organize existing ones, and even encourage additional private support.

- Stability of support is needed to achieve long-term goals. Broadly based programs of the type recommended above can be effective only when clearly defined, long-range goals have been established and stable sources of support are assured. Stable support is probably nowhere more needed than in the study of learning and its disorders.

PROSPECTS FOR THE FUTURE

To return to the original questions: Are the causes of learning disabilities in children known at a neurobiological level? Can anything be done to reverse the brain state causing such disorders? The answer is "no" to both questions. However, on the basis of this review of the literature, it seems clear that scientists have come to a turning point. The analogy of television captures the spirit of the current situation. All too often our televisions malfunction. Sometimes the malfunction is correctable by a slight trick, hitting it on the side, flipping stations, letting it rest--so that we can avoid investing in the cost of a trained repairman. Without a solid understanding of the television's mechanisms, we can only use an empirical approach developed by trial and error. Each person, in fact, may have found different tricks for the same fundamental problem. Someone more sophisticated might check the transistors. An electrician understands the television's mechanisms, can go to the root of the problem, repair it, and sometimes even make it work better.

Brains are not televisions and, in the near future, it is unlikely that the brain's machinery will be understood as the machinery of television is understood. But the progress made in the past five years, accelerated and supplemented in the manner proposed here, opens the way for an analysis of learning disabilities that is based on fundamental mechanisms. The research outlined above will help realize this important goal and help to ensure that children, the lifeblood of the nation, realize their fullest potentials. Support and nurture of this basic science approach will be, in the long run, the best way. A great future is ahead.

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B. SPECIFIC DEVELOPMENTAL DISABILITIES OF READING, WRITING, AND MATHEMATICS*

This review summarizes the scientific literature of the past five years on developmental reading, written language, and arithmetic disabilities. Reviewing this literature, particularly in the field of reading and reading disabilities, is difficult because of the lack of consistent criteria for definition and because of diverse nomenclature used by investigators. Labels used in the literature such as "dyslexia," "poor reader," or "learning disability" often fail to specify the particular attributes under study. Hence, it is difficult to know to whom research results apply.

In addition, researchers in the various disciplines may use different terminology, theories, and assumptions. According to Chall, educational researchers tend to focus on instructional research, clinical psychologists on intraindividual characteristics, physicians and neuropsychologists on etiology or brain-behavior relationships, and cognitive psychologists on theories about the reading process, particularly among skilled, adult readers. More recently, psycholinguists, anthropologists, and developmental psychologists have examined many aspects of language and learning in naturalistic settings by studying adult-child interactions and peer interactions.

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* The main source for the information on research accomplishments summarized in this section was a literature review prepared for the Interagency Committee by Doris J. Johnson, Ph.D. Dr. Johnson's full review is included in the Appendix to this report.

An impression from reading the literature is that it may be described as a series of snapshots. In reality, a series of longitudinal video tapes is needed that would permit an examination of the learner (reader) over time, across many contexts and environments. Since learning does not occur in a vacuum, such tapes would require careful analysis of adult-child interactions, with parents and with teachers, and peer interaction from early childhood through the school years.

Current research on what is called "emergent literacy" clearly indicates that the rudimentary instruction for reading, writing, and mathematics begins long before children enter school. In fact, it begins with the first picture book, with the naming of letters on toy blocks, with counting fingers and toes, or with seriating pots and pans. A host of oral language skills that form the basis for reading, writing, and numbers emerge during the preschool years. For example, children learn to differentiate pictures from print and letters from numerals, they develop a rudimentary story grammar from listening to stories, and they learn that English is read from left to right and from top to bottom.

Despite the diverse terminology and theoretical perspectives, several major issues for which there is some research evidence can be summarized.

- According to a report prepared by the Office of Special Education Programs in 1984, learning disabilities is the fastest growing category within special education.
- In 1982-83, almost 4 percent of school children in the United States were classified as learning disabled. Of those receiving special services, 40 percent of those in special education were in learning disability programs.
- These numbers are not distributed equally geographically. Keogh, in 1986, reported that 63 percent of the handicapped children from age 3 to 21 in Rhode Island were considered learning disabled but that only 26 percent were so classified in Alabama.

- Evidence from Ysseldyke at the Minnesota Institute for Learning Disabilities suggests that the special education decision process is one in which a student was referred, often for vague reasons; was automatically tested, often using technically inadequate devices; and, on the basis of inconsistent criteria, was usually placed in special programs. In certain instances, however, schools had no other alternatives for helping children with problems.

- While others have expressed similar concerns over placement criteria, McKinney has reported that in many instances specific information processing deficits among learning disabled students warranting further investigation have been identified, and form the theoretical basis for their learning disability.

- Because of the relatively vague and inconsistent criteria used in certain school systems, several researchers, including Keogh, Torgeson, and Wong, have recommended that school-identified LD subjects not be used for research without further assessment and control groups. Such efforts are essential in order to achieve a replicable body of knowledge.

To understand the nature of developmental learning disabilities and other handicapping conditions, growing evidence suggests the need for complex, multidisciplinary, interactional models that encompass biological, genetic, social, cultural, and educational factors. No single cause can account for all of the problems. Breitmayer and Ramey found, for example, that perinatal complications of all kinds occur most frequently among the disadvantaged. Furthermore, complications related to prematurity and intrauterine growth retardation are associated with intellectual and school problems, particularly if the child is reared in disadvantaged circumstances. In addition, specific child characteristics may exacerbate the effects of certain environmental factors, and some of these may be related to sex differences. According Bradley and Caldwell and to Wachs, the cognitive development of male infants is more sensitive than that of females to the effects of noise, confusion, and disorganization in the home. Inactive, placid infants show more sensitivity to environmental deprivation than active infants. Intervention studies of high-risk infants have indicated that outcomes were better when day care centers incorporated specific educational experiences rather than generalized day care. Thus, there are indications that special education is essential.

In the area of prediction, evidence suggests that multiple-instrument batteries including both teacher and parent ratings are more effective than single instruments. In addition, tests used for prediction are best when they are relatively similar to the skill being measured. Thus, knowing letter names is a better predictor for reading achievement than performance on the Bender Gestalt test.

In a recent study using the Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Badian observed 72 children who were at risk for reading problems at age 5 and, in a followup 3 years later, found 32 poor and 40 good readers. In general, poor readers were inferior to good readers on the sequential factor of the Wechsler scale but higher than good readers on conceptual knowledge.

A significant body of research now suggests that new and different measures are needed at the school-readiness level, including tasks for linguistic awareness, segmenting, and rhyming. Traditional readiness tests usually have subtests of vocabulary, listening comprehension, visual discrimination, auditory discrimination, copying, and in certain instances, mathematics. None, however, include tasks such as segmenting, auditory categorization, and orthographic awareness, all of which have been found significant in the differentiation of good and poor readers. Hence, these tasks need to be converted to standardized measures that can be used more routinely by diagnosticians, and teaching manuals at the early childhood and kindergarten level need to reflect these findings. For example, Bradley, in England, has already developed a tape to help parents teach children rhyming and rhythmic skills.

All of these studies highlight the fact that the rudiments of reading, writing, and mathematics begin long before children enter school and that parents play an important role in early reading and writing. Therefore, investigations of early adult-child interactions for possible prediction and intervention strategies would probably be useful.

READING DISORDERS

Research on the nature of reading disabilities and subtypes has increased dramatically in the last 10 years with the development of more sophisticated models of the reading process and with the use of more complex statistical procedures and technology. In general, the findings of studies of good and poor readers, or dyslexics, show that the primary disabilities are linguistic; that is, the disabilities are verbal deficits, not visual, and far fewer reversals and transpositions than previously thought account for the reading problems. According to Vellutino, if reversals occur, they result less from actual visual perceptual processes than from an analytic approach to reading. Stanovich has reported that poor decoding accounts for a large proportion of the variance among poor readers. That is, poor reading comprehension results from an inability to decode, and poor readers tend to compensate by using their background knowledge to guess at words they do not know. Other evidence suggests that some poor readers have short-term memory deficits. Other poor readers have deficits in semantic memory, listening comprehension, semantic organization, and syntax. New approaches to the study of comprehension have been developed in recent years and hold considerable promise for the future.

Good comprehensive parallel measures of oral and written language to identify specific problems have not yet been developed. For example, listening and reading vocabulary tests with identical words to determine whether the disabilities are due primarily to oral language or to reading are not available, nor are there tests to determine whether children could repeat the items on decoding tests. In addition, listening or reading comprehension tests that really measure how well people learn from listening and reading have not been developed. Such investigations are crucial for program planning and future research.

Research on the neurophysiological basis for developmental dyslexia has also increased during the past decade. For example, studies of eye movement have been made to determine whether there are differences between good and poor readers. While differences have been found in some studies, Rayner observed that explanations vary, and he concluded that faulty eye movements reflect the poor reader's inability to deal with language. Pavlidis, however, found differences even on nonreading tasks. His studies need more replication.

In an overview of other neurodiagnostic procedures, Duane stated that the primary diagnosis of dyslexia should be made with reading and psychometric tests. Research using noninvasive techniques with well controlled subjects has also been conducted. After years of research with the EEG, Hughes concluded that reading disabled subjects generally showed patterns different from those of normals, but that more investigations are needed. Similarly, research using brain electrical activity mapping has shown differences between dyslexics and normal readers, and should continue with well defined subjects and with comprehensive psychoeducational measures. The neuroanatomical studies of Galaburda offer additional data to verify the constitutional nature of dyslexia and related disabilities.

With regard to sex differences in dyslexia, Finucci says that more boys than girls are poor readers but that the extent of the discrepancy varies with the definition and selection of subjects. Others say that males are frequently better on spatial tasks than females but that variability within male and female populations is larger than that between the sexes.

WRITING DISORDERS

Research on written language indicates that most, if not all, learning disabled students have problems with some component of writing, whether it is handwriting, spelling, written syntax, vocabulary, or written discourse, but not all components are impaired in every child. This is due, in part, to the fact that written expression typically follows reading; however, there are many reciprocal relationships. Faulty writing may also be related to lack of instruction, practice, and expectancy.

Many new theories of writing development have emerged in the last decade and hold considerable promise for research in learning disabilities. For instance, research in spelling has provided developmental data that are useful for comparing normal and LD learners. Children begin to spell by using logographs, and letter names. Later, they abstract phonological features and finally the orthographic patterns. Nelson found that dyslexics made more phonetically inaccurate and orthographically illegal errors than normals. Phonological strategies are often difficult for individuals who cannot segment or manipulate sounds in words.

In general, Smith says that the good speller is a multilevel information processor who uses graphemic, phonemic, morphemic, lexical, syntactic, semantic, and etymological knowledge. A task is to determine which types and levels of information poor spellers abstract or fail to abstract, and to investigate reasons for failure. Traditional tests are screening measures at best. Other research on written language indicates that LD subjects use less complex syntax, omit more word endings, and make more punctuation errors than normals. In addition, at least some poor writers are less adept in taking the reader's perspective. Studies of good and poor writers also suggest that the latter engage in less prewriting and revising skills than good writers.

MATHEMATICS DISORDERS

Research in the area of mathematics has been slow to emerge in learning disabilities but has increased in the last decade. As with reading, underachievers in mathematics are a heterogeneous group. Some evidence suggests four primary factors play a role in mathematics achievement: language, conceptual, visual-spatial, and memory. In addition, "strategy use" is important.

The Columbia Institute found that in mathematics LD subjects used different strategies from their peers and that they were slower to develop and apply strategies for encoding and retrieving information than their peers. However, LD children can learn when provided with systematic, direct instruction.

Few LD studies have explored relationships between reading, mathematics, and spelling. Rourke found three groups: one was uniformly deficient in all three; a second group was better in arithmetic than in reading or spelling but still below expectancy; a third had normal reading and spelling but impaired performance in arithmetic. McCleod and Crump found that only 10 percent of LD students were seriously deficient in mathematics but that one-half required supplemental mathemathics instruction.

RESEARCH NEEDS

On the basis of this review, it is evident that there are many needs in the field, none of which are easily solved in a country with a diverse population, where each school system develops its own curriculum and cherishes the freedom to design individual programs of instruction and research and to generate alternative approaches for education. The country is also concerned about individuals who, for one reason or another, are unable to profit from the experiences provided in its schools. Hence, there are laws, rules, regulations, and services for those with special needs.

A major concern is the differentiation of children with learning disabilities from other underachievers. Plans should be developed for a series of longitudinal studies with comprehensive test batteries. Test batteries that include only measures of intelligence and reading or mathematics provide data about only one facet of learning and therefore do not provide sufficient data to examine patterns of performance and errors across many areas of achievement. While research will always be needed in specific areas such as decoding or spelling, poor performance in any one of these is insufficient for identifying subgroups of learning disabilities. In addition, subtypes of reading disabilities are not synonymous with subtypes of learning disabilities.

Several projects with identical procedures should be designed for studying children in various geographical regions across different socioeconomic levels. A comprehensive assessment should include, at a minimum, all areas of potential underachievement specified in the definition: listening (auditory receptive language); speaking (oral expressive language including word retrieval, syntax, articulation, and language usage); many components of reading including decoding and comprehension; several facets of writing including handwriting, spelling, syntax, and discourse; mathematics reasoning and computation; and various aspects of nonverbal behavior. Without such comprehensive studies, the relationships between one or more areas of achievement may go unrecognized and untreated in special education. Problems in reading, written language, and mathematics, for example, may be related to the same underlying language comprehension disorders. Similarly, visual-spatial disorders that interfere with handwriting may also interfere with mathematics, with self-help skills, and many occupations. Yet, unfortunately, each subject matter is often studied separately.

Other approaches to classification should be considered. Several clinicians, neuropsychologists, and researchers have already begun to identify certain problems that co-occur. Therefore, it may be beneficial to select a comprehensive test battery that could be administered to several groups of children in various geographical regions of the country. It is hypothesized that certain patterns of learning and performance would occur, irrespective of socioeconomic levels (though other factors may influence the severity). As an analogy, one finds similar linguistic characteristics with Broca's and Wernicke's aphasia whether the adult is in a nursing home or a private rehabilitation center, in either rural or urban United States. While level of severity and type of care might differ, the symptomatology is similar.

Alternative approaches to classification should be considered in order to differentiate learning disabilities from other underachievers, and to identify subgroups within the total population. Such approaches might include the identification of prototypical or exemplar cases already familiar to clinicians and researchers. The teams could then identify common characteristics or markers and do further research to validate each type. This approach would necessitate careful selection criteria, a common nomenclature, and identical tests to determine whether each subject did or did not have problems in a specified area. Such an approach may also be useful in investigating the cognitive disorders associated with specific medical conditions or syndromes.

A common nomenclature for research and practice is needed. Many studies are difficult to compare because of the varied terminology used across disciplines. Terms such as "perception," "word identification," "phonological coding," and "linguistic awareness" do not always represent the same phenomenon or skill. Therefore, for purposes of clarity, researchers should, at the very least, define terms and indicate how a particular skill was measured.

To close the research, diagnosis, and remediation gap, groups of investigators need to work closely with people in measurement and test construction to develop more reliable and valid tests. For example, since many experimental tasks on phonological awareness are highly predictive of reading achievement, they should be used more systematically, together with other readiness tests.

All experimenters should be encouraged to define the attributes of their subjects more specifically. To simply specify intellectual and achievement levels is insufficient, given the other biological, social, and cultural variables that play a role in learning. In many respects, the task of investigators, diagnosticians, and administrators has resembled a giant class inclusion exercise requiring the identification of sets and subsets of learners. Future studies should include as much detail as possible about the attributes of both the experimental and control groups, particularly if generic labels such as "good and poor readers" are used. Criteria for both inclusion and exclusion of all subjects should also be specified. Control groups drawn from regular classrooms often contain children with a wide range of mental ability and achievement. Therefore, both upper and lower levels of ability and performance should be noted. Data regarding the number of subjects who failed to meet the criteria for an experiment also provide the reader with additional perspectives about the population, tests, and experimental measures used.

Special emphasis should be given to studies of LD children with different mental age levels. Often gifted children are deprived of services if they are not underachieving in relation to grade placement. Investigations of strategy selection and usage would be particularly interesting to explore with children of low average, average, and above average mental ability. Some investigators, for example, have found that gifted students with learning problems made types of errors in mathematics that were different from those with less ability. The former were found to abstract principles easily but made computation errors because of carelessness or inability to monitor. Similar patterns of performance might be noted in written language as well.

Future research will be strengthened if investigators provide descriptions of settings from which the groups are drawn. Factors such as class size, curriculum, overall makeup of the group, expectancies, type of school and home environment, socioeconomic levels, sex and race, and parents' education and occupation all add to the understanding of learning and learning disabilities.

To achieve a more replicable body of literature, studies should provide a description of experimental tasks including content, formats, directions, materials, reinforcement, and other pertinent details. Attributes of intervention methods also should be specified. There is a tendency for people to use overly general terms such as "whole word," "phonics," or "multisensory" to describe certain approaches. Unless one has taught exceptional children, investigators may not realize the problems associated with the word "method." For example, in reading, one needs to define the type or orthography, class of word, type of sentence structure, whether the method is analytic or synthetic, type of content, familiarity of content, type of rule learning (implicit or explicit), mode of input, and forms of response. Terms such as "direct teaching" also tend to be somewhat ambiguous. The reader needs information regarding the theoretical rationale, object content, scope, and sequence. Future studies of instruction also should include careful analyses of adult-child interaction. Efforts should be made to help parents and teachers provide the directions, support, cues, and guidance to facilitate learning.

Long-term, prospective studies of intervention need to be conducted to explore the interaction of biological, social, cultural, and educational variables. Emphasis should be given to service delivery models including parental programs of intervention, preschool programs, special schools, self-contained categorical vs. noncategorical placements, resource rooms, and itinerant programs. Detailed analyses of multiple variables within the learner and the environment should be made to determine which children make the most and least progress. Efforts should be made to characterize the type of setting, environment, and stimulation in which learners thrive best. Long-term effects of childhood illnesses and trauma should also be investigated.

The mental health of children, their families, and teachers also requires study. While one cannot avoid a certain amount of stress, interviews with many LD adults raise concerns about the long-term consequences of multicategorical rooms. Many of these adults found that special education or resource rooms including behaviorally disordered and mentally retarded children along with LD children were not conducive for learning. In addition, such inclusions contributed to their loss of self-esteem. Stress on teachers in such rooms is also a matter of concern. The attrition rate in special education is increasing, not because teachers are necessarily dissatisfied with their profession but because they are "worn out" from dealing with behavior problems. Some have elected to take lower-paying teaching jobs in private centers in order to be able to work with more homogeneous groups of children.

Studies of types of mental health services for the LD population, particularly at the upper levels are also needed. Informal discussions with adults have revealed that they prefer and have profited from short-term problem solving approaches in contrast to more dynamic therapy, in which they are required to review early childhood memories.

Nonverbal disabilities and generalized conceptual (meaning) disorders should also be studied. Both types of problems may result in relatively serious social and vocational limitations. Often individuals with them have the ability to decode, spell, and compute, but they fail to comprehend the significance of words and symbols. Some, but not all, have high verbal and low performance intelligence quotients. Often they have poor spatial orientation, faulty social perception, and deficits that interfere with independence. These people are frequently of great concern to their families because of their inability to take care of their daily needs and to obtain work.

Research on career awareness and vocational rehabilitation should be combined with efforts in business and industry. Experience with LD adults indicates that the typical paper and pencil aptitude tests provide limited data about problems and modifications that may be needed on the job.

All studies related to etiology should be continued. While special education services may always be needed, it is far better to direct some energy toward prevention. Collaborative studies with neurologists, biologists, geneticists, physicians, educators, and others will hopefully add to the understanding of both normal and atypical learning.

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C. DEVELOPMENTAL LANGUAGE DISORDERS[*]

This summary comprises a description of the current research findings on the definition, associated characteristics, diagnosis, prognosis, prevalence, causes, and treatment of that category of learning disabilities termed "developmental language disorders." Each section reviews current literature and focuses on future research as well as clinical needs, as they relate ultimately to issues of prevention.

Language development requires the integration of sensory, attention, perception, cognitive, motor, linguistic, social, and emotional functions. When one or more of these functions fail to develop normally, language development may be delayed or disordered. Language disorder is often a symptom of other primary impairment, such as mental retardation, hearing loss, autism, or brain lesion. Unfortunately, language disorders that are secondary symptoms of these disorders are often merged together with primary or specific developmental language disorders based on surface symptomatology rather than on underlying etiology or common mechanisms of action. Considerable inconsistency in the research literature has resulted from a failure to adopt a uniform definition of the disorder or apply consistent diagnostic criteria. In a medical model, advancement of knowledge in a field is often evidenced by progression from definitions based primarily on surface symptomatology to ones based on understanding of etiology and mechanism of action, with improved treatment following that advance.

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[*] The main source for the information on research accomplishments summarized in this section was a literature review prepared for the Interagency Committee by Paula Tallal, Ph.D. Dr. Tallal's full review is included in the Appendix to this report.

Appropriately, research into developmental language impairment has focused on investigating the associated characteristics of these children and parsing them according to these characteristics into distinct subgroups. In this regard, two main approaches have been taken: a linguistic approach and a neuropsychological approach. In a review of the research literature, several principal findings emerge from studies following a linguistic approach.

Although language-impaired (LI) children are delayed in comparison to normally developing children in the acquisition of phonology, morphology, semantics, and syntax, few examples of frank deviance have been reported in each of these areas. That is, these children rarely produce utterances that are not characteristic of human language-based systems. Detailed linguistic analyses have demonstrated that, on the whole, what may look like an aberrant and unprincipled system on the surface can be revealed to be the output of a normal rule, one that just does not happen to hold for English. For example, the important distinction must be made between the acquisition of language-particular facts of English versus what is a possible linguistic rule. This distinction is tremendously important when it comes to determining whether language-impaired children are deviant in their ability to learn a grammatical, rule-governed linguistic system or rather delayed in mapping language-specific incidences (in this case, English) onto that system.

Research on the whole suggests that the latter is the case. That is, LI children are delayed, not deviant, in language-specific acquisition. However, results from a University of California, San Diego, longitudinal study have shown that this may not entirely be the case. Whereas each component of the language may follow this pattern individually, the interrelationship between these components may be deviant, especially in terms of order of acquisition of linguistic structure.

Another consistent finding emerging from linguistic studies of LI children is that not all of the children perform similarly. Three subgroups have been widely recognized: (1) receptive impairment, (2) expressive impairment, and (3) global impairment (receptive and expressive). Attempts to define subgroups along linguistic dimensions have been quite inconsistent from study to study, possibly because few of these studies assessed a broad enough range of abilities in the same child and few were longitudinal. Thus, one of the major focuses of the San Diego study is on questions and hypotheses pertaining to subgroupings. Some surprising results have emerged from fine-grained linguistic analyses:

- Unexpectedly, the pattern of performance both within and across language domains was the same for all LI children regardless of their subgroups.
- The receptively impaired children performed more poorly than the expressively impaired children on every linguistic measure, regardless of the structural linguistic parameter assessed.
- This quantitatively but not qualitatively different pattern of performance suggests that the impairments of these subgroups may be task-dependent; that is, they may be in areas other than linguistic knowledge per se.
- What seems to characterize differences in receptively versus expressively impaired children is their ability to access their knowledge of language under different task or processing demands. In particular, receptively impaired children are more impaired using the language they know in structured tasks and may perform much better in spontaneous speech. For expressively impaired children, the opposite is true.
- In terms of outcome or prognosis, these classical subgroups are very robust. It is clear from the San Diego longitudinal study that, in terms of language outcomes, preschool-age children who have primarily an expressive language deficit fare far better long-term than those with primarily receptive or combined receptive and expressive deficits.

These unexpected data, based on comprehensive linguistic analyses, implicate processing rather than linguistic deficits in LI children, and they make it imperative that hypotheses pertaining to a neuropsychological basis rather than linguistic basis of developmental language disorders be taken more seriously.

A second major research approach to the study of developmental language impairment has been a neuropsychological study of the perceptual, motor, memory, and cognitive abilities or disabilities of these children. A primary basis of some of these disorders lies in the phonological area. Neuropsychological searches have been undertaken that look for the biological basis of such a disorder. In an examination of a variety of neuropsychological profiles, language-impaired children differ considerably from normally developing children in the rate at which they can access sensory information converging on the nervous system. These children are unimpaired in responding to a variety of processing tasks, so long as the information is presented more slowly, but they lapse dramatically in their performance on the same tasks if the presentation is made at a greater speed. This finding is similar in the area of memory. The children who have difficulty in processing rapidly presented information--that is, nonverbal information in a variety of sensory modalities--also demonstrate memory impairment that can be exacerbated or alleviated by the rate of presentation of the information.

Investigators next asked what kind of outcome one might have in the language system that would be implicated by such a processing constraint. The language system is accessed through the auditory system, and discriminating between different speech sounds is related to the ability to integrate information, in many cases very quickly over time. In the sound "ba" and the sound "da," the differences occur over a very brief period of time, and language-impaired children have their greatest difficulty in integrating information within these kinds of speech sounds. With the use of computer-synthesized speech, investigators are able to show that this problem for language-impaired children can be alleviated by extending the duration over which these critical-frequency acoustical changes occur over time. In a wide variety of studies, it has been shown that the same pattern holds for speech production. That is, those speech sounds that are more steady-state in nature are less often misproduced than those requiring rapid motor integration and organization, like the stop consonants and consonant clusters.

An important question is the extent to which these basic perceptual motor integration processing deficits predict the degree of language impairment in language-impaired children. A variety of variables have to do with processing both speech and nonspeech sounds in the auditory modality quickly in time, and the deficits that individual language-impaired children show in their ability to process at these rapid rates are very directly and highly predictive of their degree of receptive language impairments. This disorder follows from very basic processing, through the phonological system, and into the overall extent of deficit.

Investigators have also examined the extent to which similar perceptual motor deficits in integrating information and producing it quickly over time could discriminate, or diagnose, language-impaired children from normals. Six very basic variables were found. They have something to do with either producing or perceiving very basic sensory information presented to the nervous system quickly in time--in the tactile modality, through the speech modality, through nonverbal cross-modal integration, and through verbal and nonverbal visual information; and they all relate to each other.

Taken in combination with each other, these variables correctly discriminate 98 percent of the time between language-impaired and normally developing children, regardless of their clinical subtype or surface symptomatology. This finding seems almost to be a marker variable for this disorder, which co-occurs with receptive language impairment and can be used very accurately to discriminate language-impaired from normally developing children. This result has been replicated many times in many laboratories over the last fifteen years.

Another question is the extent to which other populations show similar kinds of problems, particularly children with developmental dyslexia. Research results have shown within the dyslexic population two subgroups of unequal size. Some dyslexic children did not respond differently from normal children in integrating nonverbal auditory information quickly over time, but other dyslexic children showed a pattern very similar to that of developmentally dysphasic children. The group of auditorially impaired, perceptually impaired children were different from the group of dyslexic children because the former had concomitant oral language deficits and, specifically, decoding deficits not shown by the latter group. It seemed to follow that dyslexic children who have oral language impairments and subsequent decoding deficits look very much like dysphasic children.

These basic neuropsychological profiles were clinically useful in predicting the degree of decoding skill. That is, the more impaired a child was in processing rapidly presented nonverbal auditory information, the more impaired that child was in reading nonsense words on a decoding task.

In another approach to evaluating the relationship between language and reading disorders, longitudinal studies are consistent in linking developmental dysphasia to developmental dyslexia. These longitudinal studies directly demonstrate co-occurrence of developmental language disorders and developmental reading disorders in the same child but at different ages, with data implicating the same underlying processing deficits in both developmental disorders. Thus, developmental dysphasia and developmental dyslexia may not be two distinct disorders but rather a single developmental disability affecting specific processing constraints on specific aspects of the language/learning system at different ages.

The foregoing discussion might be conceptualized as the phenotypic or behavioral expression of specific developmental language disorders. Understanding and characterizing the phenotype of a disorder of unknown etiology, such as these disorders, is an essential foundation from which to begin research into its cause, prevalence, and treatment. Once a disorder can be clearly defined and characterized, and separated into more homogeneous subgroupings, researchers are in a much better position to investigate its origin and prevalence. Much of the literature on prevalence, etiology, and treatment unfortunately has serious methodological flaws pertaining to issues of definition and diagnosis. In the absence of a uniform definition of the disorder or of psychometrically valid and reliable measures for its diagnosis, it is almost impossible to find consistency in these research areas. For example, some studies have included, as language-impaired subjects, children with autism, mental retardation, hearing loss, and multiple other primary disabilities with symptoms of language delay, but not primary language delay. Unfortunately, they each included a different parsing of the population, which makes it almost impossible to arrive at a consensus.

Similarly, children of widely differing ages have been included in various studies, thus treating an obvious developmental (that is, changing) disorder as a static one, with devastating effects. It is not surprising therefore that prevalence estimates of language impairment have ranged from a low of 2 percent to a high of 25 percent of the population, depending on how language impairment was defined, what methods were used to assess it, and the age of the children sampled. This area needs an entirely new focus. It should capitalize on the the research into language disorders over the past 10 years that impact on definition and diagnosis, and subsequently on the development of goals and directions for future prevalence studies. Appropriate plans and programs for this population cannot possibly be formulated without accurate prevalence estimates. This is of critical importance.

Etiological research suffers similarly, because of a lack of consistency on issues pertaining to the definition of the cohort of interest. Nonetheless, potential etiologies investigated for language impairment include genetic, metabolic, hormonal, teratogenic, infectious, and psychogenic causes. On the whole, the research literature yields little support of a major psychogenic etiology. The most supported mechanism of action, regardless of whether related to genetic, metabolic, hormonal, or teratogenic has been primarily neurological. A number of these areas have provided interesting research findings in the past five years.

GENETIC FACTORS

Although clinical impressions have led to a common belief that there may be a genetic basis for specific developmental language disorders, only two controlled group studies of familial prevalence can be identified in the literature. Both studies found significantly increased incidence of positive family history in the families of LI children, but how language impairment was defined and diagnosed, and how positive family history was defined and assessed left a great deal to be desired. As part of the San Diego longitudinal study, issues pertaining to a possible genetic etiology are being investigated. Detailed family history data have been collected via parent questionnaires. Preliminary results demonstrate several fascinating new findings:

- The rate of impairment of primary relatives (parents, siblings) was significantly higher in the families of LIs than in control subjects. Interestingly, parents of LI subjects reported higher incidence of poorer language, reading, and writing performance, but not mathematics performance, than parents of control subjects.

- A very exciting result was that language-impaired children with or without affected parent(s) can be differentiated from each other remarkably well, based on their behavioral (phenotypic) profiles. LI children with affected parents (suggesting a genetic basis for their disorder) on the whole are less impaired than those without affected parents. The patterns of their neuropsychological, linguistic, and academic achievement were significantly different as well. More work is needed on these data before they can be fully interpreted, but preliminary results appear to be very consistent and robust, and will point the way toward more detailed genetic investigations of LI in the future.

The most convincing evidence for a genetic influence would be a discovery of a chromosomal abnormality in LI children. Because of the 2 or 3:1 male-female ratio, many investigators have concentrated on the sex chromosomes. Several authors report an increased frequency of sex chromosome abnormalities in LI children. Similarly, children with known sex chromosome abnormalities have been assessed for language disorders, outside of mental retardation. Of the groups studied, the only one that demonstrated specific language disorders is of XXY boys, who showed a high incidence of language, reading, and spelling problems. Also, like LI children, these XXY boys showed significant deficits in nonverbal and verbal auditory processing--specifically, discriminating and sequencing at rapid rates. These rate-processing deficits were significantly correlated with both oral and written language deficits. It is clear that language impairments have rarely been the focus of genetic research and that much more research is needed.

INBORN ERRORS OF METABOLISM

Recognizable and unique behavioral phenotypes have been described for many genetically determined diseases, and it has been reported that inborn errors of metabolism may impair behavior and development in specific ways. Specifically, there is evidence that disorders of language development occur in children treated for various errors of metabolism. Phenylketonuria (PKU) children treated by special diet for PKU early in life do not become mentally retarded. However, specific language/learning deficits do develop in some PKU children. Despite normal hearing, and nonverbal IQ, some PKU children evidence delayed language development and significant short-term auditory memory disorders. Similar profiles have been reported for children treated early in life for galactosemia, histidinemia, Laurence-Moon-Biedl syndrome, and deLange syndrome, as well as those with a variety of other inborn errors of metabolism and specific language processing disorders. Few studies, however, have undertaken a thorough behavioral evaluation to substantiate these clinical observations. Collaboration between biochemists and neuropsychologists for this purpose is presently under way as part of the new San Diego Center for Neurodevelopmental Studies.

TERATOGENS

It is well known that numerous teratogens, from heavy metals to drugs and alcohol, can affect a developing fetus and ultimately, central nervous system function. Unfortunately, few studies have focused on behavioral teratogenicity in humans, and fewer still on school-age children or on processing language/learning development per se.

Some of the best research on the consequences of prenatal toxic insult has been in the area of lead poisoning. However, in a search of the literature, only a single study could be found that adequately assessed IQ, language, and auditory processing. In this study, children with high lead levels were generally of normal nonverbal IQ but impaired with regard to verbal performance and processing and to sustained attention.

Another toxic substance shown to affect fetal development at low levels is alcohol. Children who were significantly exposed to alcohol in utero show attentional problems and learning disabilities. Unfortunately, there are no studies that have looked systematically at patterns of language and processing abilities, per se, in normal IQ children exposed prenatally to alcohol or drugs. However, as part of the San Diego longitudinal study, detailed medical history questionnaires were completed by biological parents of each subject.

Of the numerous medical and demographic data collected, only questions pertaining to prenatal exposure to potential teratogens (alcohol, nicotine, drugs) significantly differentiated the LI from the control group. The new San Diego Center for Neurodevelopmental Studies will undertake fine-grained neuropsychological and linguistic analyses of children exposed prenatally to alcohol. Much more work needs to be initiated in this important area.

BRAIN DAMAGE

Despite the etiology studied, be it genetic, metabolic, hormonal, teratogenic--there are mixed findings that the mechanism of action underlying the expression of language disorders is neurological. Developmental language impairment, with concomitant temporal processing and memory deficits, appears to be consistent with a pattern of innate or progressive dysfunction of the left temporal association cortex and/or subcortical areas subserving it. This may be due to the presence of a functional deficit with the left hemisphere, to an abnormal state of cerebral asymmetry, or to disordered interhemispheric or subcortical-cortical integration. The mechanisms by which this neurological dysfunction occurs is still unresolved. It is likely that an interaction among factors may be responsible (Ludlow and Cooper, 1983). For example, LI children may be predisposed to their condition by having inherited a left temporal lobe that is on the lower end of the continuum of normalcy, as Geschwind (1979) has suggested. Conversely, a variety of intrinsic or extrinsic factors may be responsible for an initial induction of a neurological abnormality by causing abnormal cell migration in the brain, by interfering with neurogenesis in regions of the brain where neurons continue to proliferate after birth, by interfering with the normal subtractive neural processes of neuronal death and axon retraction, or by otherwise disturbing the normal development of myelination or of the systems and structures subserving language (Ludlow and Cooper, 1983; Broman, 1983; Janowsky and Finlay, 1986). However, it is possible that not all children will be similarly impacted by such disturbances. Certain children may be subject to other intrinsic or extrinsic factors (for example, chronic otitis media), which may interact with the original factors to exacerbate (or perhaps even to compensate for) the original neurological abnormality.

It is important to remember, also, that not only do anatomical asymmetries occur in the two hemispheres but also that brain development itself is asymmetric. Homologous cortical regions do not develop simultaneously, and therefore, factors that affect the brain at a specific point in fetal life may selectively impair the development of specific cortical regions while leaving the others intact (Geschwind, 1979). Thus, the timing of neural insult may be crucial in determining which structures are most affected and, as a result, whether language development, as opposed to other types of development, will be affected.

There is a tremendous need for anatomical, physiological, and functional studies of the normally developing brain at different stages of development, especially with regard to cytoarchitectonic studies of the organization and timing of development of each area. The study of the brains of dysphasic children and adults through the use of new technological advances such as magnetic resonance imaging, electrophysiological recording, and positron emission tomography, coupled with detailed linguistic and neuropsychological assessment, is a particularly important research opportunity and priority. There is a continuing need for more longitudinal studies of normal and abnormal brain development. It is very difficult to answer pressing questions about developmental disorders from studies that cannot assess development over time. In addition, it is increasingly important for future research to gather multidimensional, multidisciplinary data from the same child--behavioral, neurophysiological, anatomical, and biochemical, as well as complete medical, social, and genetic family histories. It may be important to develop new cross-geographic collaborations to facilitate the study of a large enough sample to justify the multivariate analysis that will be needed to analyze data from such studies.

INTERVENTION RESEARCH

Intervention research thus far has focused on examining whether a particular procedure is effective in teaching a new behavior and the extent to which the procedure has generalizable effects; what related language disorders change under what condition; and which aspects of the normal language acquisition process apply to impaired children in their learning of language during treatment. Intervention research has evaluated these areas using both linguistic and auditory processing strategies. Results demonstrate that on the whole, numerous processing and language-based approaches are successful in teaching linguistic behavior to impaired children. In general, studies reported that intervention appeared effective in increasing impaired children's rate of language acquisition; however, there was inconsistency in the reports as to which procedures were most effective for which children. Variability may be related to the different characteristics of the children participating in the various studies.

Documented principles of intervention need to be available for therapists to be able to make informed decisions regarding the management of LI children--in particular, who should receive intervention, what behaviors should be treated, how interventions should be conducted, when treatment should be implemented, and for how long. Unfortunately, intervention research has provided therapists with few principles on which to rely in making these critical decisions. Rather than base their decisions on empirically determined principles of intervention, clinicians are forced to decide who and what to treat, and for how long, on the basis of their assumptions regarding language acquisition and the role of intervention. Unfortunately, what may have begun as assumption soon permutated over time into a perceived "truth," without data to back it up. To further exacerbate this sad state of affairs, decisions pertaining to "who to treat and for how long" often translates into the availability of public resources to find treatment. Uniformity across districts, counties, and States to ensure equity in services based on need rather than on resources available is a critical issue in much need of review.

PROGNOSIS

Issues of prognosis are critical to every other aspect of this review. Until the long-term effects or outcomes of a disorder are known, it is impossible to determine the extent and impact of the problem, and the need for research, treatment, and resources. Until recently, few prospective, controlled longitudinal studies in children had been made. Perhaps for this reason, coupled with the changing nature of the child during development and hence of developmental disorders, it was assumed that language-impaired children were merely delayed in the onset of language development, but ultimately "caught up" to their peers and "became normal." Although it is generally agreed that language development is absolutely central to all other aspects of human development, and in fact, is a major factor that separates humans from all other animals, there is far less research in the area of language disorders than its importance would warrant. Perhaps this circumstance is due to the long-held assumption that language-impaired children eventually get better. Research has not provided evidence to support this assumption. To the contrary, the results of every published longitudinal study have demonstrated that specifically language-impaired children do not catch up and become normal. Furthermore, as might be expected, their processing deficit, which so drastically impacts on their ability initially to access the oral language system, subsequently also precludes their ability to access other learning systems, which share critical components with oral language learning, such as reading, spelling, and perhaps some aspects of social interaction. Thus, rather than "catching up," these children fall further and further behind, as their processing and language deficits impact on their ability to learn and interact normally in other structured settings. This is not an assumption; these are empirically-based longitudinal outcome results. Language impairments can no longer be considered a minor, transitory developmental disability affecting preschool children only. Language impairments may be life-threatening, and without further resources and research, language impairments may well be life-destroying. On the encouraging side is the new knowledge gained by focusing research efforts for only a few years on language-impaired children; this new knowledge provides evidence that these children may have the potential for normal development and productive lives. A spirit of collaboration rather than competition is needed for developing the knowledge base necessary to help these children access their potential.

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D. SOCIAL SKILLS DEFICITS*

Social problems have been noted in learning disabled youths (Mercer, 1983) in addition to their problems in the academic realm (Kirk and Chalfant, 1984; Warner et al., 1980). Initially, LD youths' social problems were reported only in anecdotal accounts. Recent research, however, has documented their range and severity.

This summary addresses specific issues and research accomplishments in the fields of social ability and learning disabilities and discusses specific areas needing further research.

DEFINITIONS

Generally, social skills have been defined as cognitive functions and discrete behaviors that are performed in interacting with others (Schumaker and Hazel, 1984) and as "the specific behaviors that an individual exhibits to perform competently on a (social) task" (Gresham, 1986). Such behaviors can include verbal responses, such as making a statement, or overt nonverbal responses, such as discriminating one social cue from another (Schumaker and Hazel, 1984).

Social competence, the other variable to be considered in this context, is a more "value-laden" construct. According to Gresham (1986), social competence is "an evaluative term based on judgments (given certain criteria) that a person has performed a (social) task adequately." Social competence is closely related to the concept of social validity (Wolf, 1978), which is society's judgment that something is acceptable or "well done."

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* The main source for the information on research accomplishments summarized in this section was a literature review prepared for the Interagency Committee by J. Stephen Hazel, Ph.D. Dr. Hazel's full review is included in the Appendix to this report.

In summary, a "social skill" has been defined as a discrete learned response, whereas "social competence" is viewed as the socially acceptable performance of a smoothly flowing sequence of a variety of those responses. The following discussion is based on these definitions.

IMPORTANCE OF SOCIAL COMPETENCE

Research results have shown that individuals who are not socially competent are at a greater risk for future problems. Van Hasselt and colleagues (1979) cited research showing a relationship between inadequate social ability and poor long-term adjustment, including juvenile delinquency (Roff et al., 1972), dropping out of school (Ullmann, 1957), "bad conduct" discharges from the military (Roff, 1961), and mental health problems in adulthood (Cowen et al., 1973). These long-term adjustment problems may be the result of socially incompetent individuals' inability to form positive relationships with peers and authority figures.

CAUSES OF SOCIAL INCOMPETENCE

Gresham (1986) proposed that four kinds of social deficits result from four different causes. "Skill deficits" occur when an individual does not possess needed social skills in his or her repertoire. In contrast, "performance deficits" occur when an individual has the given skills in his or her repertoire but does not have sufficient motivation or opportunity to use them. A "self-control skill deficit" occurs when an individual has not learned how to perform a social skill because competing emotional responses prevent interacting with others. Finally, a "self-control performance deficit" occurs when an individual has learned the requisite skills but is prevented from performing them because of competing emotional responses or problems related to antecedent or consequent control.

Disparity in the causes of poor social skills performance complicates any solution to social competence problems. The complexity of the problem is increased even further when one considers the possibility that an individual might exhibit one kind of deficit with regard to some social skills and another kind of deficit with regard to others.

SOCIAL PROBLEMS

Several reviewers of the literature on social skills of LD children (Bryan and Bryan, 1981; Schumaker and Hazel, 1984) have reported that, compared to their nonhandicapped peers, LD children are less well liked and more likely to be rejected by others (Bruininks, 1978a and 1978b; Bryan, 1974, 1976; Garrett and Crump, 1980; Gresham and Reschly, 1986; MacMillan and Morrison, 1980; Morrison, 1981; Morrison et al., 1983; Scranton and Ryckman, 1979; Siperstein et al., 1978) and to exhibit increased levels of anxiety, withdrawal, depression, and low self-esteem when compared to their nonhandicapped peers (Cullinan et al., 1981; Kasen, 1972; Rosenthal, 1973).

SOCIAL SKILLS DEFICITS

Given that social skills are important for life adjustment and that some LD individuals exhibit adjustment problems, it becomes important to determine whether LD youth exhibit social skills deficits in areas required for successful social adjustment. Numerous studies have compared LD and non-LD individuals' performance of certain social skills. In a review of these studies, Schumaker and Hazel (1984) concluded that, on the average, LD individuals exhibit deficits in social skills areas related to social competence as it has been defined in the literature.

Although the methodologies of the studies reviewed do not allow one to determine how individuals within the LD population perform, how subgroups within the population perform, how LD youths might perform in natural vs. contrived situations, and how poorer performance of certain skills relates to peer acceptance and overall social adjustment, results overwhelmingly lead to the conclusion that members of the learning disabled population demonstrate social deficits. Moreover, these deficits occur in home settings and school settings and are perceived by LD children's teachers and parents as well as their peers (Gresham and Reschly, 1986).

PREVALENCE OF INADEQUATE SOCIAL SKILLS PERFORMANCE

Although LD youths as a group have been found to exhibit social skills deficits, it remains unclear whether these deficits are common to all LD youths or if they are exhibited by only a certain percentage of the youths in this population. Some data on this issue have been presented by Schumaker and colleagues (1982), who found that, although youths in an

LD group performed significantly fewer components of the majority of social skills being assessed when compared to their non-LD peers, the LD youths exhibited more variability in their performances. Thus, social skills deficits do not appear to be characteristic of all LD youths; they do, however, appear to be problematic for a major subset of these youths.

CHARACTERISTICS ASSOCIATED WITH SOCIAL SKILLS DEFICITS

If not all LD youths exhibit social skills deficits, certain characteristics may be found among those youths who do. Bruck (1986) identified four possible characteristics: poor patterns of cognitive functioning, more severe learning disabilities, the feminine sex of the youth, and hyperactivity. Bruck emphasized that while none of these factors alone accounts for social or emotional problems, in combination they may provide clues about which children are at risk.

CHARACTERISTICS OF SOCIAL SKILLS DEFICIT PROBLEMS

Two hypotheses have been proposed to account for LD youths' social skills deficits. Proponents of the first argue that social skills problems are primary and result from neurologic dysfunction similar to the processes that are responsible for the academic problems of LD youths. Proponents of the second state that social skills deficits are secondary and result from academic problems; that is, academic problems cause LD students to become rejected or isolated from others and thus prevent their social skills from developing in the same way as those of other children. Neither hypothesis by itself is likely to be correct; rather, both sources are probably responsible for the observed social skills deficits in LD youths.

MAJOR AREAS OF RESEARCH

Assessment

Social skills assessment is critical to the whole process of social skill remediation. Youths who exhibit social skills deficits must be identified, the reasons for the deficits must be determined, the specific social skills that should be learned must be pinpointed, and the youth's progress in a prescribed remedial program must be traced. An ideal social skills assessment tool for LD youths would address all these areas and demonstrate the following characteristics:

- It would be based on LD individuals' empirically validated social skills deficits.
- It would be psychometrically acceptable.
- It would be practical to use in school settings.
- It would span the age ranges from preschool through secondary school.
- It would allow assessment of all skills required for social competence (overt verbal and nonverbal behaviors as well as cognitive skills).

To date, such an assessment tool has not been developed. In fact, no single available assessment tool appears to approach the above requirements.

A number of assessment devices have been developed for measuring social skills performance, including sociometric systems, teacher-ranking systems, behavioral rating scales, interviews, and observation codes and checklists. Some of these have been used with LD youths; however, no instrument has been designed specifically for measuring LD individuals' social skills, nor does any one instrument meet all the requirements for an ideal assessment device. As a result, some authors (Brockman, 1985; Hops et al., 1985; Schumaker and Hazel, 1984) have recommended using a combination of devices to cover all the required functions adequately.

Research Recommendation:

- An assessment device or a package of assessment devices that meets the requirements specified above is needed. A primary consideration should be the usability of the device(s) for teachers, since most treatment of LD individuals takes place in the schools.

Skill Selection

Appropriate skill selection is central to successful social skills training. The skills selected must be valued by LD youths and contribute to their success in social situations; otherwise, they will be unlikely to use the skills.

In spite of the importance of skill selection, appropriate procedures in this area have yet to be identified. A variety of approaches have been used, including: (1) reliance on the intuition or clinical judgment of the trainer or program developer, (2) interviews with potential trainees, their parents, teachers, and other significant persons in the youths' lives about skills considered to be important, (3) reviews of relevant research literature to determine what skills deficits or problem areas have been identified for the target population, and (4) observations of youths during social interactions in a variety of social situations with a variety of individuals. Each method has strengths but also suffers from potential problems and limitations. Consequently, research is needed to help program developers and trainers identify the most appropriate skills for LD individuals.

Research Recommendations:

- Research is needed to identify common social demands and problematic situations for LD youths.
- Observational research also needs to focus on youths who are judged to be socially competent by their peers and teachers. It should span the age range from young children to young adults in a variety of interactions with peers as well as with individuals who are younger and older than the target youths. An attempt should be made to identify and name the skills these individuals use in various social situations, especially situations that have been identified as problematic for LD youths through naturalistic observation methods.
- Research should be conducted on social validity measures as they relate to the selection of skills. The types of instruments and questions which are most helpful in identifying whether the correct skills were taught need to be determined. In addition, the best methods for obtaining judgments of social validity need to be identified.
- Research should focus on identifying a taxonomy of social skills; that is, social skills should be organized according to scope and sequence and related to different ages.

Skill Design

Once certain global skills have been identified as needed by LD youths who exhibit social skills deficits, it becomes critical to identify the components of those skills and the qualitative aspects that lead to the most positive responses from other persons. However, a standard method of determining the components of a social skill, the sequence in which those components should be performed, and the qualitative aspects related to those components have not been specified.

For the most part, developers of social skills programs have relied on their own intuition and their professional and clinical experience in designing social skills. Four alternatives to this approach have been used: (1) having the youths in the target population design the skills themselves, (2) having relevant "others" (including age-appropriate peers) in the youth's environment design the skills, (3) utilizing direct observation of naturally occurring situations in which the skills are to be used and subsequently correlating observed skill components with the reaction of others to the individual performing them, and (4) utilizing observation of large numbers of individuals' performances in role-playing situations to design skills.

Although these four methods have been used in isolated studies reported in the literature, it is unclear which method yields skills that are highly accepted by trainees and the people with whom the trainees interact.

Research Recommendations:

° Research is needed to develop and apply standardized methods to the design of components of a wide variety of social skills needed by socially incompetent LD individuals at various age levels. In addition, methods for designing the sequence of the skill components should also be developed. To validate skill components as acceptable and appropriate, the input of age-appropriate youths appears to be paramount.

° Additional research is needed to develop and apply standardized methods of specifying the qualitative aspects of each component of a skill. That is, such factors as response duration, latency, timing, content, and format should be considered.

° Research should address the development of means through which social skill components and their qualitative aspects can be socially validated by age-relevant populations.

Cognitive and Decision-Making Skills

The study of LD youths' social skills performance and deficits has raised the question of what role cognitive factors play in facilitating or inhibiting acquisition and performance of social responses. The cognitive factors that have been considered include thinking and reasoning processes and extend to perceptions and beliefs about events in the world.

Cognitive factors can affect a youth's social ability or performance in at least three different ways: (1) they may influence the ability to learn a social skill; (2) they may influence the ability to perform a specific social skill at appropriate times once the skill has been learned; and (3) they may play a role in regulating emotional responses, such as anxiety, which can hinder acquisition and performance of social skills.

Research Recommendations:

- Research is needed to determine how cognitive events are related to social perception, discrimination, decision-making, problem-solving, and social awareness. How does LD youths' social performance suffer as a result of a lack of these cognitive skills?

- Research is needed to identify the exact nature of the cognitive skills that are related to social performance. Are some skills more important than others? Do some cognitive skills present more common problems for LD youth than others? Research is also needed to evaluate the relative contribution of each of these cognitive skills and strategies to social skills performance.

- Research is needed to determine how these cognitive skills should be taught to best enhance social skills ability. What strategies are most effective for teaching the use of these cognitive skills? Are the instructional approaches that are useful for teaching the cognitive skills also effective in teaching social skills?

- Research is needed to establish the effects of various cognitive strategies on emotional responsiveness. How do these approaches affect emotional responses and hence the acquisition of social skills? Which of these approaches is most helpful for LD youth in the acquisition and performance of social skills?

Instructional Procedures

In addition to specifying the social skills needed by some LD youths, procedures for increasing the successful use of these skills in social situations must also be identified. A variety of intervention procedures have been developed to improve social performance. The choice of intervention must depend on the source of the target social skill problem.

Currently used social skills improvement approaches can be divided into three categories: (1) instructional procedures designed to teach new skills to youths who have skills deficits or a self-control skill deficit; (2) approaches that focus on manipulating antecedent or consequent events to remediate social performance deficits; and (3) self-control procedures designed to increase a youth's control over his or her own social behavior and eliminate inappropriate behaviors. (Recently published curricula that have been developed to meet the need for effective training programs for social skills deficient youths are noted in the references with an asterisk.)

Research Recommendations:

- Research is needed to establish the causes of poor social skills performances in LD children and adolescents. Are their deficits the result of poor learning, poor motivation, competing emotions, or combinations of these factors? If LD youths' social problems stem from multiple causes, research is needed to identify the frequency with which various causes lead to social problems and whether the use of particular skills is related to particular causes. Such research would help guide the development of effective intervention programs for LD youths by matching instruction to the targeted problems.

- Research is needed to develop programs for LD youths with self-control performance deficits and self-control skill deficits. If a significant number of LD youths do not perform well in social situations because of competing emotional responses, programmatic research is needed to validate remediation programs for youths with these kinds of problems.

- Research is needed as the basis for development of novel instructional approaches for social skills training. Although it is relatively clear which instructional principles should be incorporated into an effective social skills training sequence, research is needed to identify practical but novel ways to integrate and use these principles in instructional settings like the classroom.

- Research is needed to design approaches to social skills instruction in the regular education classroom. In many cases, social skills instruction for LD youths is conducted in the special education classroom where LD students are isolated from regular education students.

- Research is needed as part of the development of teacher training models that will facilitate implementation of social skills training programs.

Generalization Training

Appropriate and long-term usage of social skills across a variety of settings, people, and situations should be the goal of any social skills training program for LD students. In the final analysis, social skills usage must be under the control of naturally occurring contingencies within social interactions vs. contingencies external to such interactions (Hake and Olvera, 1978; Stokes and Baer, 1977). Furthermore, generalized social skills usage must lead to the social acceptance of an LD individual who prior to training was rejected, neglected, or otherwise labeled as socially incompetent.

To date, only a small number of studies in the LD field have been conducted on generalization of effects of treatment. Principles such as teaching relevant behaviors, explaining when and where to use the behaviors, pointing out how the behaviors are related to natural contingencies, using multiple stimulus and response exemplars, and telling the youths to generalize have been applied. Based on only a few ways of producing and measuring these effects in LD youths, studies indicate that LD youths can generalize their use of skills across people and time; however, unless generalization training is undertaken outside the training setting, such effects tend to be inconsistent.

Results indicate that training methods that extend into the natural environment can successfully promote LD individuals' generalized use of social skills. To date, however, there is no evidence that social skills training impacts the social acceptance of LD individuals who were previously labeled socially incompetent, nor has any research been conducted to determine whether LD individuals' use of newly acquired social skills is maintained over time.

Research Recommendations:

- Research needs to be conducted to validate the most effective methods of promoting LD students' generalized use of social skills outside the training setting at various ages.
- Researchers need to develop and test ways of measuring generalization of social skills across settings, situations, people, and time.
- Research needs to address how much social skills training LD youths need at various ages to impact their social acceptance by peers and others in their school and community environments. Thus, the goal of generalization training should not be simply to ensure that a youth uses social skills in a generative way. The ultimate goal is to ensure the social acceptance of the youth. Thus, it is critical to determine what kinds of interventions are needed to make this kind of impact.

The Relationship Between Physiological Factors and Social Behavior

Several authors have recently noted the possible relationship between social behavior and physiological factors. The question is whether certain types of social behavior can be influenced by the introduction or elimination of a particular food, food additive, or environmental agent such as dust, pollen, or lead. The underlying notion is that a youth whose body is intolerant of a particular type of environmental substance or food or who demonstrates a chemical imbalance or deficiency will feel bad physically (headache, stomachache, rashes, urinary disorder, muscle and joint disorders) or psychologically (weepy, depressed, angry, excessively tense and fatigued for no apparent reason) (Alder, 1978; Schauss, 1984). As a result of poor physical-psychological states, the youth may withdraw socially, be hyperactive, become aggressive and destructive, be noncompliant, have tantrums, be unable to sustain play activities, and display a host of other inappropriate social behaviors--most of which interfere with appropriate social interactions--even if the youth has previously learned appropriate social skills. Conceivably, if such states are continuous, they may interfere with a child's learning of new social behaviors while maturing.

Although the research in this area is contradictory and inconclusive because of problems in experimental methodology, a growing body of research is lending some credence to the notion that the social behavior of a small subgroup of children and adolescents may be related to the foods and other substances they ingest and encounter. Several authors (Menzies, 1984; Rodell, 1985; Schauss, 1984) have concluded that the cumulative evidence supports further work in the area.

Research Recommendations:

- Research is needed which replicates and further extends the work conducted to date on sensitivities to foods and food additives. Experimental methodologies should be improved as part of such replications. Interdisciplinary teams of medical and behavioral researchers working together are recommended to ensure acceptance by both behavioral scientists and the medical community.
- Research is needed that further explores the role of chemical imbalances in learning disabled children and the effects of such imbalances on their social behavior. Once imbalances are identified, methodologies such as reversal designs should be employed using double-blind procedures with individual children to explore the effects of intervention. Again, interdisciplinary approaches representing collaboration between medical and behavioral researchers are needed.

- Research is needed to distinguish the differences and similarities between the sensitivities and chemical imbalances of learning disabled and other problem children. That is, do LD children constitute a subset of a population of children who exhibit these sensitivities and imbalances, or are they different from the larger population of children with sensitivities and imbalances? If so, such differences need to be to be explored to determine their effects on the childrens' social behavior.

- If the results reviewed here are supported, practical and efficient methods of identifying sensitivities and chemical imbalances need to be designed so that children's individual needs can be identified and treated at an early age to prevent social problems.

- Practical treatment methods need to be designed, experimentally validated, and specified in an easily understood form. Since parents will naturally be in charge of a child's daily treatment regimen, methods of educating parents about sensitivities and chemical imbalances and of maintaining children's treatment regimens must be developed.

- Ways of combining treatment regimens for sensitivities and chemical imbalances with social skill training programs need to be explored for those children and adolescents who continue to exhibit social skill deficits after their behavioral excesses have been eliminated through other means.

SUMMARY

The ability to perform well in social situations is prerequisite to successful functioning in life. Many LD youths exhibit poor social ability in a variety of situations; however, the exact nature of these social problems, their cause, type of remediation needed, and the role of various cognitive and emotive factors remain undetermined.

The major research efforts in the field of learning disabilities have focused on the academic problems and deficits of LD youth. Because social problems are a reality for a significant number of LD youth, research is needed to delineate their causes and cures.

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E. HYPERACTIVITY/ATTENTION DEFICIT DISORDER*

It is appropriate and fitting that what is termed "attention deficit disorder" (ADD) should be a central focus of any discussion of learning disabilities, since ADD is found to coexist so frequently in persons with LD, and to complicate their diagnosis and treatment. It affects children from their earliest infancy, through school age, and into adolescence and adult life. While ADD has captured the imagination of investigators and clinicians alike for almost 50 years, an explosion in the number of investigations examining every conceivable facet of ADD has occurred over the past decade. This review of selected issues in the recent scientific literature on ADD focuses on delineating the nature of ADD and how best to approach specific research questions dealing with the condition as it relates to LD.

OVERVIEW

Historical Perspectives

What is termed "ADD" had its origins in the late 19th century when physicians first observed the association of behavioral symptoms following an insult to the brain. Throughout the early part of this century, specific kinds of insults (for example, head injury and infections of the central nervous system) had been linked to a constellation of behaviors termed the "brain damage" syndrome. By the late 1930s and 1940s, Dr. A. A. Strauss and his associates had promulgated the notion that these behavioral manifestations could themselves be evidence of brain damage. Rather than starting with known brain injury causing a particular constellation of behaviors, Strauss considered the abnormal behaviors, in and of themselves, indicative of brain damage. Over time, the occurrence of the behavioral symptoms without a history of brain insult was termed minimal brain damage, and then minimal brain dysfunction.

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* The main source for the information on research accomplishments summarized in this section was a literature review prepared for the Interagency Committee by Bennett A. Shaywitz, M.D. Dr. Shaywitz's full review is included in the Appendix to this report.

By the 1960s, the term minimum brain damage (MBD) was used to designate children not only with a particular constellation of behaviors (primarily hyperactivity) but with learning deficits and minor neurologic signs. Those children whose primary problems related to learning deficits came to be called specific learning disabilities, while those children with primarily behavioral disturbances were usually labeled as hyperactive, a term codified in a diagnostic manual published in 1968 (Diagnostic and Statistical Manual-II [DSM-II]). In the 1970s, classification systems for behavioral disorders emerged. The systems employed specific criteria to either include or exclude particular patients. A later version of the diagnostic manual (termed DSM III rather than DSM II) was published in 1980, which provided even more specific criteria to be used in identifying children with what the 1980 manual termed ADD.

These historical trends can best be conceptualized as successive stages in the evolution of current concepts of ADD. In the first stage, the agglomeration of abnormal behaviors associated with known insults to the brain (including such behaviors as hyperactivity, perceptual problems, clumsiness) was viewed in a global fashion--that is, the presence of any number of the behaviors was considered indicative of a brain damage pattern. The next stage of evolution involved identifying and describing among the diffuse patterns of behaviors comprising the brain damage syndrome those behaviors most important in diagnosing a child as having minimal brain dysfunction. Three broad categories were identified, including learning deficits, neurologic dysfunction, and behavioral symptoms. In the next stage of evolution, behavior was disentangled from learning deficits, a process most reasonably considered as distinguishing the components of MBD. Such progress now permitted making distinctions within the behavioral domain, and accordingly, investigators identified a constellation of behaviors, including hyperactivity, restlessness, impulsivity, aggression, distractability, and short attention span. These six behaviors were then combined to form three specific behavioral constructs in DSM III, and specific inclusion and exclusion criteria were established for three general constructs (hyperactivity, impulsivity, inattention). As indicated below (see Critical Issues), the process to date has employed neither empiric validation of the DSM III constructs nor operationalization of the diagnostic criteria.

Causation

A host of biologic and environmental factors have been linked to the development of ADD. Among the biologic factors, genetic influences are extremely important. Evidence from a number of investigations (including those involving known genetic abnormalities, family, twin, and adoptee and foster rearing studies) indicates a strong genetic influence in ADD. From a clinical perspective, such evidence often permits the clinician to make a reasonable statement to parents about the suspected cause of the child's problems: "Your child was born that way. You seem to have had similar problems, too."

Evidence from several lines of investigation now supports the belief that such genetic biological factors may be related to abnormalities in neurological function, in particular to disturbances in brain neurochemistry involving a class of brain neurochemicals termed "neurotransmitters"--specifically, those neurotransmitters known as catecholamines. Support for this hypothesis was derived from pharmacological studies. For almost 50 years, it had been known that the symptoms of ADD are ameliorated by stimulant medications such as amphetamine and methylphenidate. Furthermore, stimulants act via brain catecholaminergic systems. This commonality led many investigators to suggest that ADD may be related to catecholaminergic systems.

Clinical studies of children now support the role of catecholamines in the genesis of ADD. Such studies involve measuring the amounts of the catecholamines in body fluids of children with ADD. Studies from a number of different laboratories have shown that the metabolites of the catecholamines are reduced in the cerebrospinal fluid and the urine of children with ADD, and reduced still further by stimulants.

Catecholamines and their metabolites originate both in the brain and in the peripheral nervous system and other body organs, such as the adrenal gland. A method is needed to examine noninvasively the actions of the catecholamines in the brain itself. Newer strategies have recently become available to accomplish this goal. It is now possible to measure minute quantities of certain of the catecholamine metabolites in the blood and urine of children with ADD. By administering a pharmacologic agent (for example, methylphenidate) known to stimulate catecholamine systems, it is possible to measure the effects of the drug on the catecholamine systems and relate these chemical changes to behaviors (Shaywitz et al., 1986a). Furthermore, it is now possible to isolate the quantity of the catecholamine derived from the brain from that originating in the rest of the body. With the use of this novel strategy, it is now possible for the first time to determine the relationship between the particular chemicals in brain and changes in behavior measuring the concentrations of catecholamines and their metabolites in blood and urine. This strategy thus provides a noninvasive "window" on brain neurochemical systems.

It is also possible to examine the metabolism of the brain in awake human subjects utilizing the technique of positron emission tomography. Such a procedure, which involves administration of radioactive products to patients, is not usually permitted in the United States for use in well children. However, results from such studies performed in Sweden by Lou et al. (1984) on children with learning and attention problems indicate reduced blood flow in particular areas of the brain. Following administration of the stimulate methylphenidate, commonly used in the treatment of children with ADD, the blood flow was increased in these areas. Most recently, Zametkin et al. (1986) utilized PET technology to examine the metabolism of glucose in the brains of the hyperactive parents of hyperactive children. They found abnormalities of glucose metabolism in particular brain regions in these people, which adds further support for the belief that neurological mechanisms are influential in ADD.

Clinical Characteristics

ADD is a low-visibility but high-prevalence disorder that can permeate every dimension of a child's life. In a sense, the term "low visibility" is a misnomer. It refers to the "normal" appearance of ADD children, not to the impact that the disorder may have on the child, his family, his class, and his community. The basic features of the disorder, inattention, impulsivity, and at times, hyperactivity, may interfere with the child's adjustment in every phase of existence, both through time and across situations and experiences. The intrusion of the child's symptomatology into every sphere of his existence, his failure to get along with family members, and his failures at school and with peers represent a source of frustration and disappointment to both the child and his parents.

Although the manifestations of the disorder may change as the child matures, ADD does not go away. Peer relationships are characterized both by low acceptance and by rejection. These findings are of particular concern since peer relationships are considered to be an important index of later adjustment. Studies of adolescents indicate that while certain symptoms may diminish (primarily hyperactivity), others such as academic difficulties, behavioral problems, poor peer acceptance, low self-esteem, and at times, depression, may persist. Indeed, secondary problems relating to aggression, poor self-concept, impaired peer relationships, and poor school functioning may become prominent components of the clinical picture. Long-term studies indicate that, although many of the symptoms persist, previously hyperactive young adults fare better in the work place than they did in the classroom.

In addition to specific symptoms of the disorder, certain overall trends or characteristics are also evident. Symptoms diagnostic of ADD manifest a developmental trend; that is, up until age 3, activity levels increase, but then show a downward trend, so that by adolescence, gross motor hyperactivity is no longer present. However, attentional deficits persist. Awareness of this developmental pattern is particularly important because it is at times mistakenly assumed that with the disappearance of the hyperactivity, the child is free of problems and no longer in need, for example, of special education services. It is critically important that parents and professionals, particularly educators, appreciate the differential ontogeny of the activity and attentional components of the syndrome.

Not only do the symptoms of ADD vary over time; they also exhibit situational variability. Both the environmental context and the task demands placed on the child influence the symptomatic expression at any particular time. The variability extends to different settings and situations and also refers to the often-lacking predictability of the child's behavior from minute to minute or day to day, even in similar situations. While the thrust of recent investigations points to an inherent vulnerability, indications are that the expression of this vulnerability is very much dependent on the so-called "goodness of fit" between the child and his environment. An interactional model in which both the child and the child's environment are constantly influencing one another and modulating the behavior of the other appears most appropriate for understanding emergence of symptoms in ADD and as such has significant implications for intervention.

This capsule summary of research into the clinical characteristics of ADD indicates that ADD is a chronic disorder affecting the child's home, school, and community life. The primary symptoms of the disorder manifest a developmental pattern in which activity diminishes while attention deficits persist. Major sources of concern are the secondary and often more resistant problems of learning difficulties, behavioral problems, lack of peer acceptance, and low self-esteem. An often frustrating and perplexing characteristic of the disorder is its marked variability over time, across situations, and within the same child and similar situations.

Treatment

Management of ADD represents a complex and intricate balance of a variety of treatment strategies encompassing educational, cognitive-behavioral, and pharmacological interventions. Establishing the diagnosis comprises the initial focus of management. Once this has been accomplished, the diagnosis and its implications must then be interpreted to the child, his parents, and key school personnel. Generally accepted management of ADD encompasses two domains: (a) nonpharmacologic (educational and cognitive-behavioral, and other psychological and psychiatric approaches); and (b) pharmacologic therapies. This review of management would not be complete, however, without a discussion of a third general class of therapies, what can be termed (c) nontraditional, controversial, idiosyncratic approaches to therapy.

Educational management represents an important priority and often forms the cornerstone of all other therapies, nonpharmacologic or pharmacologic. Cognitive-behavioral therapies (CBT) represent the most widely employed alternative to pharmacotherapy. Although the effects of CBT alone are disappointing, recent studies suggest that such therapies may provide a useful adjunct to pharmacotherapy and may be helpful when children are tapered off medication. Psychotherapy or a combination of psychotherapy and medication (termed multimodality therapy) may also be useful.

Pharmacotherapy for ADD originated 50 years ago, and at the present time the ameliorative effects of medications in ADD are well established. Despite concerns in the early 1970s that medications, primarily stimulants, were being prescribed too frequently, recent data and the experience of most clinicians indicate that this is not the case. The general skepticism of experienced clinicians, coupled with a climate where parents are reluctant to medicate children, serves to limit their use except where indicated. While the effects of stimulants on attention and activity seem well established, effects on cognition, conduct, and social behavior are more controversial. Within recent years, much has been learned about the pharmacokinetics of stimulants in children with ADD, which provides a sounder basis for administration. It is also clear that side effects are minimal, the most serious being the possibility of the emergence of tics. While stimulants are clearly the most effective agents, tricyclic antidepressants and monoamine oxidase inhibitors may also be effective.

Nontraditional, controversial, and idiosyncratic therapies continue to be used in ADD, both by professionals and laymen alike. To date, there is no indication that for most children such approaches as a food-additive free diet, elimination of sugar, megavitamin therapy, patterning or treatment of alleged vestibular dysfunction have any benefit above their placebo effects. Although appealing because of their simplicity, their adverse effects are not often recognized. Thus, they may divert parents' energies from more effective management strategies, are often expensive, and may have long-term side effects not apparent now.

CRITICAL ISSUES

Girls with ADD

Girls may represent a group of children with ADD who may not readily come to attention. When boys and girls with ADD are compared, many of the clinical characteristics found in girls are similar to those described for boys. However, there are several important differences. In the first place, girls with ADD have an increased frequency of cognitive and language deficits and increased social liability; that is, their relationships with their peers are often much more impaired than those found in boys. However, at the same time, girls with ADD exhibit far less physical aggression and loss of control than do boys (Berry et al., 1985). The implications of such a difference are very important since, in general, the symptoms of aggression and loss of control often bring ADD boys to someone's attention. Therefore, it is not surprising that girls with ADD represent an underidentified, and as a result, underserved population that is at significant risk for academic, social, and emotional difficulties.

ADD without Hyperactivity

Currently, three subtypes of ADD are recognized by DSM III. ADD without hyperactivity (ADDnoH) is used to describe children with inattention and impulsivity, while ADD with hyperactivity (ADDH) is used to describe those with inattention, impulsivity, and hyperactivity. ADD residual type (ADDRT) indicates older adolescents with a history of ADDH at a younger age but who no longer exhibit hyperactivity although the inattention and impulsivity persist.

There are significant differences not only between ADD children and normal control children but also within the groups of ADD children themselves. ADDH children and ADDnoH children, for example, differ in terms of behavioral, academic, and social patterns, though both groups exhibit inattention. Children with ADDH demonstrate what are referred to as externalizing behaviors, behaviors such as hyperactivity that are obvious to observers external to the child. In contrast, ADDnoH children tend to have symptoms not as obvious to an observer, though the symptoms may be as disabling or more disabling than the symptoms found in ADDH children. ADDnoH children, for example, are more anxious and often have poor school performance. One study (Lahey et al., 1984) found a rate of retention in the same grade of 72 percent in ADDnoH children compared to only 17 percent of ADDH children.

The implications of this are very significant: children with ADDnoH are far less visible and less likely to come to the attention of parents, educators, or other professionals; but at the same time, they may be at much greater risk for school failure and social failure than children with ADDH. A priority of research is a clearer delineation of this group of children, particularly in terms of the relationship between ADDnoH and learning disability.

Relationship to Learning Disabilities

Good evidence indicates a significant overlap between ADD and LD, yet the relationship is unclear, with co-occurrence rates varying, in no small measure because of the inconsistent criteria used to diagnose both ADD and LD. However, two recent studies (Halperin et al., 1984; Shaywitz, 1986) have found that approximately 10 percent of children diagnosed as ADD also demonstrate LD. There is considerably more variation in the percentage of children diagnosed as LD who also can be defined as ADD, with rates varying from 33 percent to 41 percent to 80 percent (Holobrow and Berry, 1986; Safer and Allen, 1976; Shaywitz, 1986).

What is clear, however, is that many ADD children have significant academic achievement problems apart from what may be termed "learning disability." They perform below expectations in reading and arithmetic, fall significantly behind in academic subjects, and fall behind in more academic subjects than do controls. One recent study found that ADD children are seven times more likely to experience "very much difficulty in all academic areas" (Holobrow and Berry, 1986).

A recent study (Sandoval and Lambert, 1985) showed that not only reading achievement but also hyperactivity and particularly hyperactivity in association with aggression was significantly related to referral for special education; in fact, twice as many hyperactive as non-LD control children were receiving special education services.

The implications of these findings are very important for research studies. The findings demonstrate that subject selection for LD based on children selected by an educational system (referred to as "system-identified") carry an inherent bias: criteria for selection employ behavioral criteria, not necessarily the criteria of LD. This observation means that any data derived from such studies will by necessity be biased and inaccurate as well, and will tend to show that hyperactivity and aggression are common in LD children. This is particularly important because, as investigators have shown (Shaywitz et al., 1986d; Trites, 1979), hyperactivity may also be associated with extreme degrees of giftedness or above-average learning capacity.

In the future, investigations must recognize that LD and ADD are related but that the nature of the relationship is not well defined. Such studies must employ well-defined, non-system-identified children, in whom the diagnosis of both LD and ADD is made on the basis of rigorous criteria. Only through such studies can the prevalence of the co-occurrence of ADD and LD be delineated and the mechanism of their interaction and effect on each other be elucidated. Such studies are fundamental to development of more effective intervention strategies for ADD and LD.

Diagnostic Imprecision

Difficulties in precisely defining ADD represent still another critical issue. The diagnostic system currently in use (DSM III) specifies that the diagnosis of ADD depends upon whether the child exhibits particular qualities. These qualities, termed "constructs," include inattention, impulsivity, and if the diagnosis is ADDH, hyperactivity as well. Each of these constructs represents a series of symptoms. For example, the construct of inattention may include symptoms such as: often fails to finish things he or she starts, often doesn't seem to listen, easily distracted, has difficulty concentrating on schoolwork or other tasks, and has difficulty sticking to a play activity.

In this system, the diagnosis of ADD is made if it is decided that the child satisfied particular diagnostic criteria. There are inclusion criteria: To be diagnosed ADD, the child must exhibit sufficient symptoms of inattention so that the construct "inattention" is deemed present, and sufficient symptoms of impulsivity so that the construct of "impulsivity" is satisfied. There are also exclusion criteria: To be diagnosed ADD, the child may not have symptoms of schizophrenia, affective disorder, or severe or profound mental retardation.

The validation of these diagnostic criteria has never been rigorously examined. Thus, despite the widespread acceptance of this diagnostic system, it must be recognized that the constructs, symptoms, or diagnostic criteria themselves employed in DSM III are not based on empiric studies and, when all is said and done, simply reflect a consensus of what experienced clinicians believe ADD should be.

Much of the confusion in the field may be considered to reflect two general problems: diagnostic inconsistency and the use of measures that are not adequate for the task at hand.

Diagnostic Inconsistency

Each group of investigators uses different operational definitions of ADD. This inconsistency creates considerable confusion, since it means that the notation "children were diagnosed according to DSM III criteria" has little meaning. Thus, in some studies, ADD is diagnosed on the basis of an informal history, in others by a chart review, and in still others on the basis of diagnostic instruments using scales that preceded development of DSM III constructs. Even when newer instruments are used with scales reflecting DSM III constructs, these scales may be operationalized differently by different investigators.

Inadequate Measures

The most commonly used measure to identify ADD children, both in research studies and clinically, is the behavior rating scale. However, there often exists a lag between the behavior rating scale used and the development of particular constructs. Thus, scales labeled hyperactivity or inattention may not reflect the current constructs of hyperactivity or inattention. For example, the Conners rating scales commonly used in studies of ADD were developed for use in drug studies long before the DSM III criteria were described. At the time these scales were developed, the behavioral symptoms were conceptualized more globally: symptoms of hyperactivity, aggression, and inattention were combined. Thus the Conners scales identify samples that are heterogeneous for attention, activity, and aggression. An important caveat is that the children identified as ADD by such instruments may not have inattention as their primary feature, but rather an agglomeration of behaviors. Just because a scale is labeled "attention" does not mean it measures attention. Investigators must look at the actual item content of a scale rather than simply rely on the label appended to the scale.

Selective Referral Patterns

Another critical issue is how the representativeness of the sample affects the outcome of the research study. Questions that must be addressed are: How representative is the clinical sample, first, of children with the disorder, and second, of children referred for professional consultation?

What today is termed "ADD" evolved most recently from the hyperactive child syndrome. Rather than hyperactivity, the primary focus is now on inattention, and hyperactivity need not be present. This change in focus has had a number of significant influences on how ADD is viewed. For example, when hyperactivity was the major focus, behavioral disturbance was considered to be the prime symptom and hyperactive children were likely to be referred to psychiatrists and mental health centers. With the change in focus to attention deficits, poor school work and learning difficulties were often the principal reasons for referral. Furthermore, children with inattention were more likely to be referred to pediatricians, child neurologists, or learning disorders units rather than to mental health centers.

It is becoming increasingly apparent that selective referral patterns ensure that significant biases are built into any study of ADD employing children referred to mental health settings. For example, Loney and Milich (1982) found aggressive symptoms in two-thirds of children diagnosed as hyperactive in a mental health clinic, compared to aggressive symptoms in only 18 percent of hyperactive children in a classroom sample. In another study, this time from New Zealand (McGee et al., 1984), three groups of hyperactive children were identified by parents and teachers: hyperactivity only, aggression only, or hyperactivity in association with aggression. Those with hyperactivity alone were judged to be least severely affected while those with hyperactivity in association with aggression were the most severely affected, with the referral rate for the most severe group six times that in the less severe groups.

The implications of these studies are extremely important for the children and their families. One consequence is that the number of affected children may be seriously underestimated. ADD children who are inattentive and who have learning problems but who are not hyperactive or aggressive may be overlooked and underrepresented in study samples. Thus, children described as ADD in mental health clinics may represent the "tip of the iceberg" and not the entire spectrum of ADD.

Still another consequence of this selective referral bias is that nonrepresentative associations may emerge that are not typical of most children with ADD. For example, the association of conduct disorder and aggression in children with ADD derived from mental health settings. Any generalizations from studies of these mental health center populations of ADD children to ADD children in the general population may not be appropriate. Thus, rather than regarded as prototypical of all children with ADD, children referred to a mental health center may represent the extreme of the continuum.

It follows that current and future investigations must recognize the range and severity of the symptoms encompassed by ADD. Studies of ADD must be multidisciplinary if they are to be representative of the entire spectrum of the ADD population. The research design must include not only the expertise but the diverse patient populations of those disciplines currently involved in evaluating and treating children with ADD (disciplines that include pediatrics, psychology, education, child neurology, and child psychiatry). In addition, the research design should include a comparison population of children who have not been referred to any professional. Such a research strategy is fundamental to an examination of the full range of children with ADD. The range includes not only the easily identified child with hyperactivity and conduct problems along with inattention, but, most importantly, those less visible and currently underidentified children primarily with inattention.

A major need for research is to study homogeneous groups of children and to be able to identify or describe the particular population included in the sample. Because ADD may be accompanied by other disorders, the term "ADD," indicating ADD alone, without any other complicating feature, should be utilized; and "ADD-Plus," should be used to indicate that ADD is present in association with some other complicating factor--for example, ADD in association with conduct disorder (CD), affective disorder, mental retardation, or oppositional disorder. In this way, the reader of a report on ADD will have a much more precise picture of exactly which group of ADD children has been studied.

Many knowledgeable investigators have recognized that any further advances in the understanding of ADD mandate the empiric validation of diagnostic criteria. As indicated previously, the diagnostic criteria proposed in DSM III represent nonvalidated, nonoperationalized constructs. Recent investigations have described newer instruments that reflect the DSM III constructs, such as the Yale Children's Inventory (YCI) (Shaywitz et al., 1986b). The YCI, which is a parent questionnaire, was developed to characterize and define children presenting for evaluation of school-related problems, with special emphasis on attention deficits. The YCI has excellent reliability, and recent studies indicate excellent concurrent and predictive validity with a number of different measures.

Factor analysis of the YCI demonstrated 11 narrow band scales, representing such qualities (constructs) as attention, hyperactivity, impulsivity, conduct disorder, academic performance, fine motor ability, and language. The narrow band scales were then grouped into two broad bands, termed "behavior" and "cognitive." What is so interesting is that attention overlapped both the cognitive and behavioral domains. This important finding indicates the centrality and intrinsic relationship of attention to both behavioral and cognitive functions. Furthermore, it strongly supports the DSM III nosology for attention deficit disorder.

New Diagnostic Model for ADD

There are two important steps in the diagnostic process for ADD: (1) definition and operationalization of the constructs, and (2) the actual criteria for diagnosis; that is, while the rating scales measure the construct, how is this information used to provide a diagnosis?

Using the constructs provided by the YCI, investigators wanted to determine if they could develop an empirically based diagnostic model for ADD that would differentiate children with ADD from normals as well as differentiate ADDH from normals, and ADDH from ADDnoH. Beginning with children diagnosed as ADDH, ADDnoH, or non-ADD based upon the "Best Estimate Diagnosis" described by Leckman et al. (1982), they developed a multistaged, hierarchical logistic regression model. This multistage diagnostic procedure is used in a hierarchical fashion. In stage 1, children are classified as high, medium, or low risk, based upon the score on the YCI attention scale. In stage 2, those in the medium risk group are diagnosed as normal or ADD, based upon the results of a logistic regression equation. Finally, in stage 3, children are diagnosed as ADDnoH or ADDH, based upon the results of a second logistic regression equation.

In an initial sample, the diagnostic model just described was found to have a sensitivity of 88 percent, which indicates that 88 percent of cases of ADD were correctly classified as ADD. The specificity, indicating the proportion of normals correctly classified as normals, was 94 percent. In a replication sample, sensitivity was found to be 94 percent and specificity 77 percent (Shaywitz et al., 1986c). Studies are currently in progress to examine the diagnostic model in other samples to reflect multidisciplinary sources.

The findings of this attempt to empirically validate DSM III criteria for ADD suggest a more cautious approach in accepting these criteria. The YCI scales represent a modification of DSM III criteria; they correspond to the DSM III constructs conceptually and have many overlapping items. They represent a step forward in that they have emerged from empiric studies and have proven psychometric properties.

The good discriminant validity shown by the YCI scales together with their sound psychometric properties represent the initial steps in the validation process for ADD. External validation studies are now in progress and may help clarify issues relating to etiology, natural history, response to treatment, and outcome. In the future, large-scale multidisciplinary studies employing homogeneous subgroups representing not only ADD but also learning disabilities and conduct disorder will be necessary to establish a reliable and valid nosology for ADD.

IMPLICATIONS AND RECOMMENDATIONS

There is an enormous need for a large, multidisciplinary, multicenter study of ADD to define the entire spectrum of ADD. Such a panoramic view of the disorder is critical to providing a classification system for more clearly defining and diagnosing ADD, and the relationship between ADD, CD, and LD. This strategy is central to a delineation of homogeneous subgroups so necessary in the conduct of external validity studies.

External validation, including other biologic approaches, must be incorporated into any classification paradigm. Thus, advances in technology have provided noninvasive techniques that permit examination of neuroanatomical, neurochemical, and neurophysiological measures. Such techniques as magnetic resonance imaging and positron emission tomography offer the possibility of not only imaging the brain in better detail than ever before but of providing information about regional brain metabolism and blood flow. Furthermore, neurochemical measures, particularly those involving brain catecholaminergic mechanisms, offer for the first time an opportunity to examine central catecholaminergic systems in children with ADD. Clearly, the success of such strategies depends on the better delineation of clinically homogeneous subgroups as described above.

What is needed are large-scale studies of representative samples of both normal and clinic populations in which the clinic populations reflect the full range of severity and associated features characteristic of ADD. By necessity, such studies require a multidisciplinary approach, involving the full range of disciplines that are called upon to evaluate and manage the child with ADD. Assessment measures are now available to select homogeneous subgroups of children according to operational definitions of ADDH and ADDnoH children with and without complicating features of, for example, learning disabilities and conduct disorder. Identification of relatively homogeneous subgroups of children selected in this manner would represent a first step in a classification process for ADD. The validity of such a nosology could then be further examined through internal and external validity studies. An important component of such studies would be a longitudinal strategy in which the sample, the symptomatology, and the outcome measures are clearly defined from the onset. Incorporation of these methodologies would represent the most efficient and productive approach to the elucidation of the mechanisms and optimal management of ADD.

Such a study is mandated by the recognition that it is only through the identification of the broad spectrum of ADD that it will be possible to recognize those underidentified and currently underserved children who are perhaps of the lowest visibility, the children with ADDnoH and LD but with minimal hyperactivity and conduct problems. At the present time, children often selected for LD programs have strong evidence of hyperactivity and aggressive symptoms. Those who are nonhyperactive and nonaggressive ADD--that is, those with ADDnoH--fall between the cracks and are presently often not identified. The first stage of treatment is identification, and children who are never identified as having a problem can never be treated. Thus, the current practice of identification of LD on the basis of hyperactive and aggressive behaviors presents a catch-22. It leads to the assumption that because children with hyperactive and aggressive behavior are identified as LD, then such symptoms themselves are symptoms of LD. Such may be true in some cases, but it denies services and overlooks the quiet, ADDnoH child.

ADDnoH children need greater visibility. They may have high intelligence but may not function up to their ability, not because of conceptual reasons, but because of inattention, carelessness with details, and problems monitoring their work. Because these children may not have externalizing signs, they are faulted for poor motivation, for not trying harder than anyone else. It is not surprising, therefore, that the most rapidly accumulating data indicate that this group of children is at the highest risk for academic difficulties and poor self-concept.

Such findings mandate specific priorities for public policy. There must be a national effort to better define and understand the full spectrum of ADD, clarify the relationship between ADD and LD, and make parents and educators aware of ADD (particularly ADDnoH) and its implications, particularly the educational implications. This educational effort must ensure that children with ADD realize their full potential and are not continually penalized for exhibiting the problems associated with their disorder.

It must be recognized that ADD encompasses the spectrum of intellectual ability. For example, children falling into this underidentified, underserved category of ADDnoH have been found even at the highest levels of intelligence, and sometimes these are the children penalized the most. They are penalized not because of conceptual limitations, not because they do not understand, but because educators often fail to recognize the symptom complex and make the small modifications that would allow for success--modifications that could include such simple strategies as allowing extra time on tests or allowing a child to type. The educational effort must extend from the primary grades, through college, and even graduate school.

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VI. RECOMMENDATIONS OF THE COMMITTEE

The act mandating the establishment of the Interagency Committee on Learning Disabilities requires that the Committee in its Report to Congress make "recommendations for legislation and administrative actions--

(A) to increase the effectiveness of research on learning disabilities and to improve the dissemination of the findings of such research; and

(B) respecting specific priorities for research in the cause, diagnosis, treatment, and prevention of learning disabilities."

The recommendations contained in this chapter are the result of deliberations of the Interagency Committee based upon information, suggestions, and recommendations from three major sources: the Public Hearing held by the Committee; the literature reviews prepared by expert consultants and presented and discussed at the National Conference on Learning Disabilities; and the review of the research activities of the Committee member agencies. After extensive discussion at several Committee meetings, members agreed on the following recommendations.

DEFINITION OF LEARNING DISABILITIES

A foremost consideration that has impact on all areas of the requested recommendations is the issue of definition. The concept of learning disabilities is one that has evolved over time. One of the first formal definitions was developed in 1967 by the National Advisory Committee on Handicapped Children and later incorporated into legislation in

P.L. 94-142. This definition has been the standard applied in determining eligibility for services under that law. It reads as follows:

> "Specific learning disability" means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.

As more has been learned about learning disabilities from research, and as people have attempted to apply this definition in a variety of settings, numerous shortcomings of the definition have become apparent. It wrongly implies that learning disability is a homogeneous condition rather than a heterogeneous group of disorders. The use of "children" in the definition fails to recognize that for most people a relative disability persists and affects them throughout adulthood as well. It does not indicate that, whatever the etiology of learning disabilities, the final common path is an inherently altered process of acquiring and using information, presumably based on an altered function within the central nervous system. Finally, though properly recognizing that learning disabilities do not include problems with learning as a consequence of mental retardation, sensory or motor handicap, emotional disturbance, or socioeconomic or cultural disadvantage, the definition does not clearly recognize that persons with those conditions may have learning disability in addition to, if not as a consequence of, their other handicap.

In an attempt to deal with these concerns, the National Joint Committee for Learning Disabilities in 1981 developed a revised definition. This definition has been endorsed by most professional and lay organizations in this field, and all organizations and individuals who addressed the issue of definition at the Public Hearing held by the Interagency Committee urged the Committee to adopt the revised definition. That definition is as follows.

> Learning disabilities is a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual and presumed to be due to central nervous dysfunction. Even though a learning disability may occur concomitantly with other handicapping conditions (e.g., sensory impairment, mental retardation, social and emotional disturbance) or environmental influences (e.g., cultural differences, insufficient or inappropriate instruction, psychogenic factors), it is not the direct result of those conditions or influences.

The Committee believes that this new definition represents a substantial improvement and reflects the conceptual advances that have emerged from research in the past two decades. However, some problems remain. In recent years, there has developed a consensus that social skills deficit also represents a specific learning disability. The Committee has included this disability among the topics it has reviewed in this report, and believes it should be added to the definition. Second, the relationship between attention deficit disorder (with or without hyperactivity) and learning disabilities is not addressed. The Committee believes that there is evidence that attention deficit disorder may be best considered in the same category with other conditions that may either accompany learning disabilities or cause learning problems (but not disabilities), and thus should be added to the definition. Finally, the fact that these handicapping conditions cause learning problems but not what is intended by the term learning disabilities is not clear in the definition, and should be specified.

Therefore, the Interagency Committee[*] proposes a modification of this revised definition of learning disabilities, and believes that it should be considered for use in epidemiologic studies of the prevalence of the condition, in diagnosis, in research, in administrative actions, and in future legislation. The modified definition is as follows (changes underlined):

> Learning disabilities is a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities, or of social skills. These disorders are intrinsic to the individual and presumed to be due to central nervous system dysfunction. Even though a learning disability may occur concomitantly with other handicapping conditions (e.g., sensory impairment, mental retardation, social and emotional disturbance), with socioenvironmental influences (e.g., cultural differences, insufficient or inappropriate instruction, psychogenic factors), and especially with attention deficit disorder, all of which may cause learning problems, a learning disability is not the direct result of those conditions or influences.

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[*] The Department of Education cannot endorse the proposed change in the definition of "learning disabilities" for these reasons:

> 1. The inclusion of the "significant difficulties in the acquisition of and use of ... social skills" will necessitate a change in the Education of All Handicapped Children Act (EHA). A change in the EHA would result in increased confusion in the criteria used to determine who is eligible for special education services and who is not eligible. Since the Department of Education is making an effort to return to regular classrooms those children who do not have true learning disabilities but who do have learning difficulties, the inclusion of those children with "social skills" deficiencies would increase rather than decrease the number of children who would be classified as learning disabled and eligible for special education services.
>
> 2. The last phrase of the proposed definition--"...a learning disability is not the direct result of those conditions or influences..." is questioned by the Department's legal advisors. They question the use of the word "direct." The attorneys point out that the sentence could logically read, "Even though...a learning disability is the indirect result of those conditions or influences." The question is, "Does that mean that a learning disability is an indirect result of those conditions? If so, what happened to the concept that a learning disability is intrinsic to the individual?"

PERSONS AFFECTED BY LEARNING DISABILITIES

Another cross-cutting issue addressed to the Committee was to assess the number of persons affected by learning disabilities. For a variety of reasons, the Committee found the studies conducted to date to be totally inadequate to provide anything more than a wide-ranging estimate of this number, and concluded that further study is necessary to provide an accurate estimate of the prevalence of learning disabilities in this country. Such an endeavor should not be undertaken until there is a national consensus on a definition of learning disabilities, and inclusionary and exclusionary criteria have been agreed upon and standardized. When these goals have been met, the Committee recommends that a sufficiently large study be carried out to determine the actual prevalence of learning disabilities, in which students are individually tested, and those who are found to have learning problems are further evaluated in order to discover underlying etiologies, some of which may differentiate those with learning disabilities from those whose learning delay is due to other causes.

ACTIONS TO INCREASE THE EFFECTIVENESS OF RESEARCH ON LEARNING DISABILITIES

At this stage in the evolution of research on learning disabilities, the Committee concludes that collaborative, integrated, and coordinated multidisciplinary approaches to research questions, such as could be undertaken on university campuses in large program projects and in specialized research centers of excellence, would be the most appropriate way to increase the effectiveness of this research. In research supported by these mechanisms, the effectiveness of the whole is often greater than the sum of the parts. The approach would resemble the Federal effort now being successfully applied to addressing mental retardation, Alzheimer's disease, nutrition, diabetes, and other major U.S. health problems. The literature on learning disabilities, which is still somewhat fragmented and in the past has been dominated by competition between theories and approaches, now contains a sufficiently large information base for interdisciplinary teams of investigators to devise broad and longitudinal multidisciplinary approaches that integrate and capitalize on what is now known. Large program projects and the creation of research centers would provide opportunities to bring neuroscientists, biologists, geneticists, epidemiologists, anatomists, psychologists, physicians, educators, and others together for intensive multidimensional studies of various populations of learning disabled persons and of carefully selected subsets, as individuals as well as groups, along with normal control groups.

A major goal of this research should be the development of a classification system that more clearly defines and diagnoses learning disabilities, conduct disorders, and attention deficit disorders, and their interrelationships. Such information is prerequisite to the delineation of homogeneous subgroups and the development of more precise and reliable strategies for treatment, remediation, and prevention that will increase the effectiveness of both research and therapy.

Research on learning disabilities, whether individual projects or large team efforts, should address the entire range of the biomedical and behavioral research spectrum, from the intensely basic, to the highly applied, and to be maximally effective must ultimately include assessments and evaluations of demonstration and education strategies. The research should also make use of advances in noninvasive techniques that permit examination of neuroanatomical, neurochemical, and neurophysiological measures, including magnetic resonance imaging and positron emission tomography.

ACTIONS TO IMPROVE THE DISSEMINATION OF RESEARCH FINDINGS

The establishment of research centers and multidisciplinary program projects for learning disabilities research will itself improve the dissemination of research findings and help to remedy a generally perceived problem of information sharing. Regular joint meetings of the investigators in these centers to discuss research progress and even plan collaborative studies using common protocols would further facilitate this process. In addition, center-based multidisciplinary research would reduce cross-disciplinary gaps in communicating research findings and accelerate the transfer of information to practicing clinicians. It will also contribute toward hospital-based, school-based, and community-based counselling and education of families affected by learning disabilities.

To further remedy problems of information sharing, a formal system of information dissemination through a central clearinghouse should be implemented, which would facilitate communicating information to target populations in need of it, such as practicing pediatricians, parent groups, and trainers of teachers. Such clearinghouses have been effective for other disorders, and the field of learning disabilities is now clearly ready for and in need of such an effort. In addition, LD training workshops for the various professional groups, including physicians, psychologists, and educators, should be encouraged, and the development of model training programs would be helpful. A special need is dissemination of information about the relationships between LD and attention deficit disorders, particularly when hyperactivity is absent.

A further means of both developing and disseminating information is through demonstrations of service delivery through regional, family-centered, and community-based systems of care. The focus should be on development and dissemination of new techniques of serving LD children and adults and the integration of efforts to meet health, educational, and psychosocial needs.

SPECIFIC PRIORITIES FOR RESEARCH

Advances in the basic knowledge of the causes of learning disabilities can lead to the development and refinement of diagnostic techniques and tests for specific disabilities and to the identification and evaluation of strategies and modalities for their treatment and prevention. The degree of accuracy and refinement of information from these sources contributes to the reliability of epidemiologic data, and the findings of epidemiologists provide clues to basic investigators, diagnosticians, and clinicians for their further research efforts. The scientific community now knows enough about learning disabilities to bring these various parts together through multidisciplinary collaborative efforts, which should include long-term studies of prevalence and treatment outcomes.

Any approach to identifying particular areas for research on the cause, diagnosis, treatment, and prevention of learning disabilities has to recognize that these research categories are not disparate, but are interrelated entities. Clinical studies of strategies for treatment or remediation of a specific learning disability, for instance, might generate a wealth of data, which serendipitously closes up an information gap about causes and leads to a breakthrough in basic science, with implications that go far beyond what was initially sought.

Although the Committee has arranged its recommendations under the categories of cause, diagnosis, treatment, and prevention, there is frequent overlap, and the category under which each recommendation is located is merely suggestive of a research emphasis or focus.

Cause

The causes of most learning disabilities remain unknown. It is essential to understand the environmental and genetic factors that cause these disabilities, because true, primary prevention cannot occur until the causes are known. Since the majority of etiologic associations have derived from in-depth clinical, laboratory, and etiologic studies of patients affected with a disease, it is very important that such etiologic studies be made of persons with LD and appropriately selected controls.

It is important to understand the mechanisms by which environmental and genetic factors cause LD because a better understanding of the mechanisms will provide information that will be helpful in primary, secondary, and tertiary prevention. Substantial research into mechanisms should be in the basic sciences, especially the neurosciences. In order to identify and elucidate the mechanisms of learning disabilities, better knowledge is needed of how the brain develops and functions. Early brain development, for example, is a period of special vulnerability. Although neurotoxicity produced experimentally by exposure to chemicals is associated with learning and memory deficits, it is not known to what extent these exposures contribute to the human condition of learning disabilities. Research is needed, therefore, to determine when and how during ontogeny the cognitive processes, including learning and memory, are vulnerable to toxic insult, and what specific toxic substances, if any, are involved.

In a related area, poor social skills performance in LD children and youths may be a result of poor learning, poor motivation, competing emotions, or a combination of these factors. Research should be conducted on the causes of poor social skills performance, including multiple causes and their interrelationships.

Areas for research on the causes of learning disabilities include the following opportunities and needs:

- In basic neurobiology, research on the mechanisms of synaptic transmission and plasticity within the mammalian central nervous system should be expanded. Further research is also needed, with the use of techniques of cell biology, on the mechanisms of synapse formation in the developing and mature brain. Questions of how synaptic contacts are formed, modified, and maintained in the brain are central to any biological theory of learning. More broadly, a better understanding of the neurobiological basis of behavior is needed, and an effort should be made to identify early biological and behavioral markers of learning disabilities, which would alert practitioners to a need for timely interventions.

- Anatomical studies--including work on primate postmortem tissues-- should be made of the brain at different stages of development, especially with regard to cytoarchitectonic organization and timing of development of each area. This area of investigation should include the study of structures believed to be involved in learning disabilities. The study of brains of children with severe LD who have met with accidental death would also be important. Studies that relate neuroanatomical structure with physiologic and chemical function are also needed, including studies that monitor brain function during learning in patients with learning disabilities. New neuroimaging techniques, including PET scanning, magnetic resonance imaging (MRI), and computer-averaged EEG, are only the beginnings of what may play a key role in this area.

- The circuitry and integrative actions of cortical networks are too complex to study without the aid of accurate simulations. Sophisticated computer systems, which allow detailed reconstruction of the various systems, already exist that would be valuable not only for the analysis of information processing capacity but also for constructing better computer models of relevant brain circuitries. Such simulations aid in verifying hypotheses from animal studies and also predict new ones to be studied in vivo. Additional and more greatly detailed computer simulations of various cortical-subcortical systems involved in memory are needed. In addition, expected deficits in circuits should be modeled to determine functional consequences.

- Efforts to develop animal models appropriate for the study of the biological bases of learning disabilities should be expanded. Animal models should also be used to identify chemical, environmental, nutritional, and other risk factors associated with the development and manifestation of learning disabilities.

- Researchers have found that the kinds of errors made by gifted students with learning disabilities are often different from the kinds made by students with less ability. Studies should be made of LD children with different IQ levels. Research should also be directed to elucidating the similarities and differences between children with a variety of developmental disabilities, with a focus on etiology rather than symptomatology.

- Interdisciplinary efforts are needed to improve methodologies for research on chemical imbalances and sensitivities to foods and food additives. Research should include efforts to distinguish the differences and similarities between such imbalances and sensitivities of learning disabled children and those of children with other problems.

- Research is needed to develop and improve procedures which evaluate perinatal exposure to chemical teratogens on the developing brain. This research should include improving behavioral and cognitive testing, monitoring for the presence and distribution of the teratogen in the nervous system, understanding mechanisms of action on the developing brain, and determining dose-effect relationships. Selection of chemicals for study should reflect potential human exposure or suspicion of developmental neurotoxicity.

- Population surveillance of developmental disabilities should be developed that monitors unusual occurrences for clues to possible etiologies as well as natural histories, including factors that influence these etiologies. The potential contribution of exposure to man-made or naturally occurring chemicals to the etiology of learning disabilities should be examined by rigorous epidemiologic and clinical laboratory studies, particularly case-control studies. Rigorous studies, such as randomized clinical trials, would be needed to determine if intervention prevents the disability.

Diagnosis

A problem in diagnosis has been a lack of uniformity in the use of terms in the research literature. For appropriate diagnosis to be made, the inclusionary and exclusionary criteria based on the definition of learning disability need to be operationalized and standardized so that consistency in making differential diagnoses across laboratories and clinics can be established. A taxonomy of social skills is also desirable.

Areas for research that would improve the ability for diagnosis include the following opportunities and needs:

- More reliable and valid diagnostic strategies for identifying learning disabilities are needed. Cognizant Federal agencies should bring together investigators in LD along with specialists in measurement and test construction to develop diagnostic criteria and strategies, including assessments and provisions for periodic updating and revisions. The results should help close the gap between research, diagnosis, and remediation, and enable early identification of at-risk subtypes.

- Social skills deficits, recently recognized as both independent disabilities or disabilities associated with other learning disabilities, represent a new area of research. Research needs to be conducted to determine whether the social skills deficits of such individuals differ from those of non-LD socially incompetent individuals. If differences are determined, an assessment device or package of assessment devices should be developed, with emphasis on usability in schools.

- An ability to identify early biological and behavioral markers of learning disabilities is needed.

- Information is needed about the interrelationships between cognitive processes and emotional processes of LD children and adolescents, and also between LD and coexisting psychiatric disorders.

Treatment

The literature on learning disabilities has a large amount of information about treatment, but thus far, the results of much of the research tend to be inconclusive or conflicting. Because of the lack of uniform diagnostic criteria and the heterogeneity of populations selected for study, the findings often have limited generalizability. The scientific footing on which treatment and remediation strategies are based is therefore in need of intensive broadening and strengthening. More rigorous research strategies and clinical trials are needed to examine regimens of intervention. It is essential that both the populations being studied and the diagnostic criteria used be defined for an evaluation of treatment.

Particular research opportunities and needs in treatment include the following areas:

- Long-term, prospective studies of various interventions need to be conducted to explore the interaction of biological, psychological, social, cultural, and educational variables.
- Evaluations of therapies should address whether the therapies are effective for subgroups of learning disabled persons. Any therapy so identified and advocated, for which there are sufficient suggestions of efficacy, should be subjected to a rigorous clinical trial to test effectiveness and applicability.
- Research is needed on the nature, extent, and effectiveness of various types of mental health services available to the LD population; this should include studies of preventive as well as interventive services.
- Research is needed to determine how to best enhance the social skills of socially impaired LD individuals. Data are also needed on the effects of various cognitive strategies on emotional responsiveness, and on career and vocation awareness.
- Special studies are needed on effective treatment of gifted LD students. Such information could lead to long-range planning and strategies to help affected persons to actualize their potential.
- Strategies for helping parents to teach and reinforce remediation strategies at home should be developed and evaluated.

Prevention

Knowledge about preventing learning disabilities results from knowledge about cause. It is now well known, for instance, that lead ingestion can cause neurologic damage and that the damage can be prevented by removing sources of lead from infants and children. More clinical, epidemiologic, and basic research on etiology is needed, and the results should lead to strategies for prevention. In addition, an ability for early diagnosis, such as through use of biological or behavioral markers, should provide for secondary prevention of learning disabilities, or at least for averting or ameliorating disorders that might manifest later in life. At the present time, the most effective strategies for prevention are implementation of the foregoing recommendations dealing with causes, diagnosis, and treatment.